SCIENTIFIC AMERICAN
No. SUPPLEMENT 524

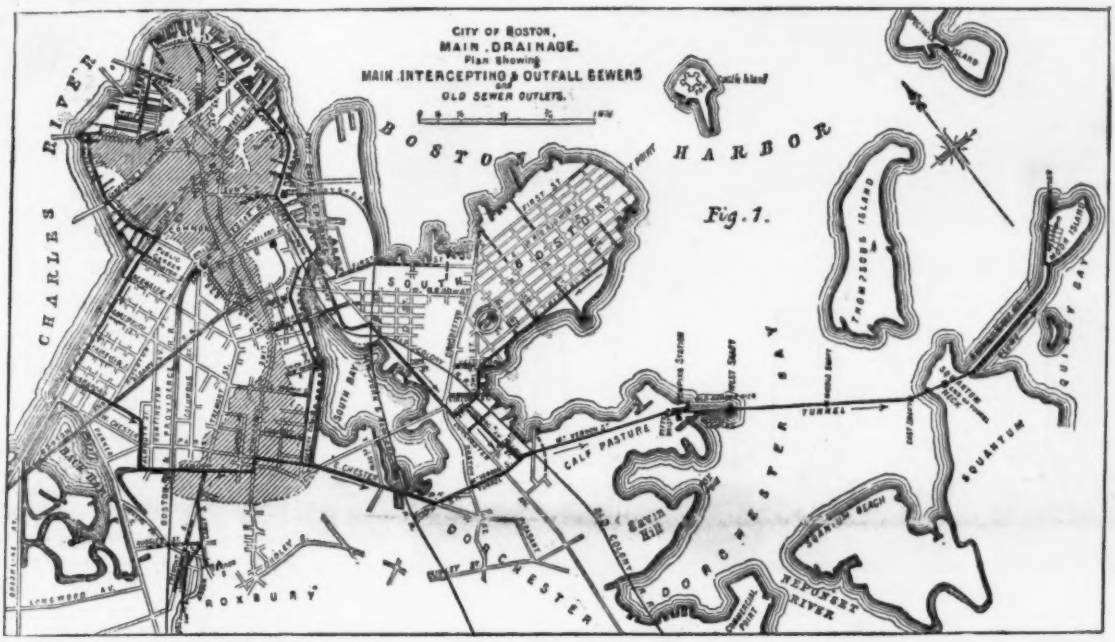
Scientific American Supplement, Vol. XXI., No. 524.
Scientific American, established 1846.

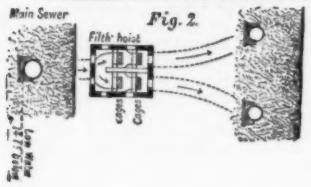
NEW YORK, JANUARY 16, 1886.

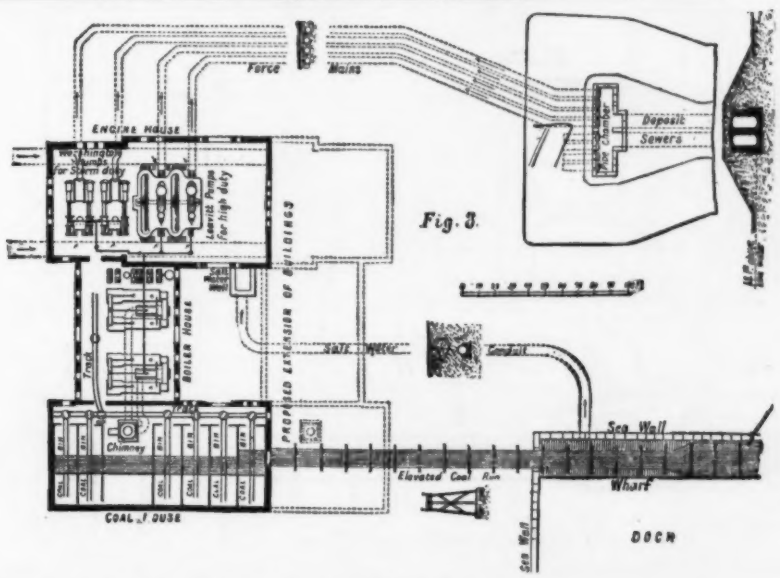
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE BOSTON SEWAGE WORKS.

A SYSTEM of intercepting sewers skirts the city, and intercepts the flow from the previously constructed sewers; these intercepting channels discharge into a main sewer that runs across the city to a pumping station on the coast at Dorchester Bay, where the sewage is raised to a height of 35 ft. into an outfall sewer to the neck of land called Squantum, which is crossed by a flume to Quincy Bay, and thence through another sewer to Moon Island, where a large reservoir is constructed that impounds the sewage which is accumulated during the latter part of the ebb and the whole of the flood tide, and is discharged into the harbor during the first two hours of the ebb tide. The map shows the general arrangement clearly. The surface water due to rainfall is not, however, all led to the pumping station, and the old sewer outlets are therefore retained, being protected by a double set of sluice gates, and the discharge level is below that of the tide. The whole of the sewage is, however, delivered on Moon Island, as well as the water from light rain, the storm water being cut off from the intercepting sewers by automatic regulating apparatus that controls the height of flow. An exception is made, however, in some of the districts subject to flooding in periods of storm; in these the old sewers have a free discharge into the intercepting sewer. At the pumping station, the sewage is delivered into separating pits, containing so-called filth hoists (see Figs. 2 and 19), which are large cages constructed of iron bars spaced 1 in. apart. All solid matter that would clog the pump valves is retained in these cages, which are lifted and cleaned from time to time, the amount of solid matter arrested being about a cubic yard per day.







THE BOSTON MAIN DRAINAGE SYSTEM.

The four boilers are of steel, each of 250 horse-power, and one is able to provide steam to the pumps in ordinary working; the coal stores have a capacity of 6,000 tons. Each of the pumps has a delivery main 48 in. in diameter. These mains deliver the sewage into the so-called deposit sewers or settling chambers. Fig. 1 indicates the position of them, and Fig. 3 shows them to a larger scale. They form one end of the tunnel with exceptional amounts of sewage in periods of rain. The average quantity of coal burned per day throughout the year is about 5 tons. Figs. 2 and 3 illustrate this part of the installation, Fig. 2 being a plan of the filth hoist pits and the discharge galleries leading to the engine house, and Fig. 3 a plan of the engine house, etc., and delivery mains leading to the tunnel across Dorchester Bay. The positions of the Worthington and the Leavitt engines will be seen from this plan; they are contained in a building constituting one wing of the establishment, the coal stores occupying the other wing, and the space between filled with the boiler house. The dotted lines show the proposed extensions.

From the separators the sewage flows along galleries built on each side of the engine-house to the pump wells (see Figs. 2 and 3). The pumping station is not completed, but forms part of a design that will be carried out gradually as the demands of the city increase.

At present there are four engines in service; two were built from the designs of Mr. E. D. Leavitt, Jr., by the Quintard Iron Works, New York, and raise 25,000,000 gallons of sewage per twenty-four hours to a maximum height of 43 ft. The other two engines were made by the H. R. Worthington Company, of New York city, and are kept in reserve for dealing with exceptional amounts of sewage in periods of rain. The average quantity of coal burned per day throughout the year is about 5 tons. Figs. 2 and 3 illustrate this part of the installation, Fig. 2 being a plan of the filth hoist pits and the discharge galleries leading to the engine house, and Fig. 3 a plan of the engine house, etc., and delivery mains leading to the tunnel across Dorchester Bay. The positions of the Worthington and the Leavitt engines will be seen from this plan; they are contained in a building constituting one wing of the establishment, the coal stores occupying the other wing, and the space between filled with the boiler house. The dotted lines show the proposed extensions.

The four boilers are of steel, each of 250 horse-power, and one is able to provide steam to the pumps in ordinary working; the coal stores have a capacity of 6,000 tons. Each of the pumps has a delivery main 48 in. in diameter. These mains deliver the sewage into the so-called deposit sewers or settling chambers. Fig. 1 indicates the position of them, and Fig. 3 shows them to a larger scale. They form one end of the tunnel and deposited outside the harbor. The levels of the depositing sewers and receiving tank are regulated so as to allow this to be effected automatically. Figs. 4 to 8 show the direction and form of the tunnel that runs from the depositing sewers to Squantum. Its total length is 7,160 ft.; for the greater part of its length it is nearly horizontal, and its invert is about 150 ft. below high water. It was built with three shafts, and runs through beds of clay slate and Roxburgh conglomerate. The shafts were sunk with iron cylinders inside cofferdams, and the ends are protected above the surface with cribwork inclosures (Figs. 5 and 6). As completed, the tunnel is 7 ft. 6 in. internal diameter, and is lined with three rings of brickwork. About 26,000,000 gallons are forced through it daily, and the deposit of sludge on the invert is insignificant. When desired, this can be scoured by pumping water through the tunnel with a velocity of 4 ft. a second.

From Squantum to Moon Island is rather more than a mile across the flats of Dorchester Bay, which are mostly uncovered at low water. An embankment is constructed along this distance, and in a part of it a

sewer 11 ft. by 12 ft. is built. For the rest of the distance the sewage flows through a wooden flume of the same dimensions. A gallery passes along the front of the reservoir on Moon Island, and the sewage is discharged into it through sluices (Figs. 13 to 16). The reservoir shown in Fig. 1 is made to hold 25,000,000 gallons of sewage. It covers five acres and is inclosed within retaining walls, being also divided by partition walls into four sections, any one of which can be shut off for cleaning or repairs. The floor is of concrete, and brick-faced gutters are provided, as shown in Figs. 11 and 18. The time for discharge is one hour after each high tide, when the current sets well out to sea and the sluice gates are opened for about forty minutes. Fig. 9 shows the galleries through which the reservoir is emptied. Figs. 10 to 18 show the construction and arrangement of the reservoir and of the inlet and discharge sewers.

Figs. 19 to 23 are illustrations of the high-duty engine and engine-house; Fig. 19 being a section through the receiving pits and filth cages, and Fig. 20 enlarged section of the pipe chamber and deposit sewer junction. The general arrangement of the engine consists in placing the cylinders, which are vertical and inverted, directly over the pumps, with the beam midway, or nearly so, between them, its journals being carried on the bed-plate. The steam cylinders are supported by an entablature carried on eight columns, bolted to the bed-plate, while the pumps are hung underneath the latter by strong brackets, N N, and are also supported by girders, P, built into the masonry at the base of the

Fig. 4

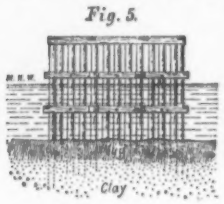


Fig. 5.

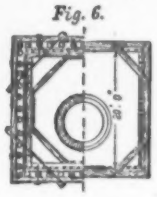


Fig. 6.

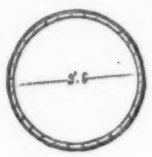


Fig. 7.

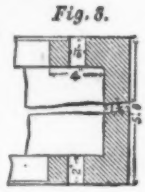


Fig. 8.

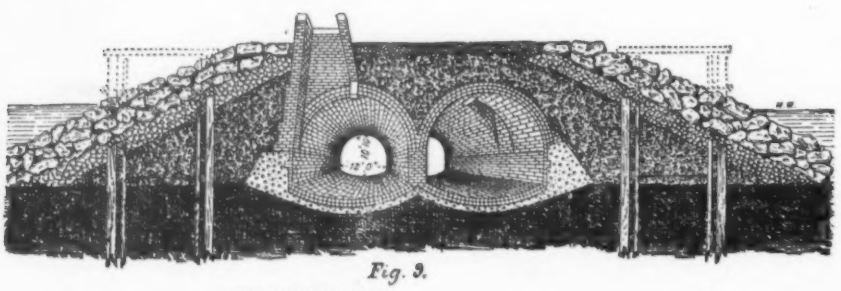


Fig. 9.

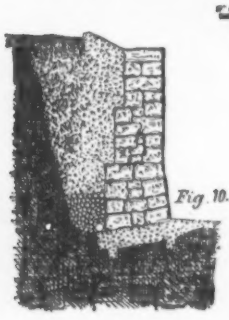


Fig. 10.

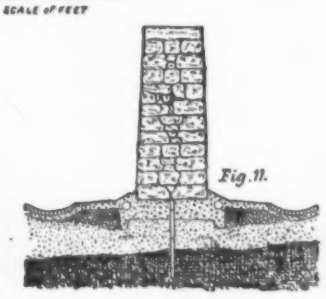


Fig. 11.

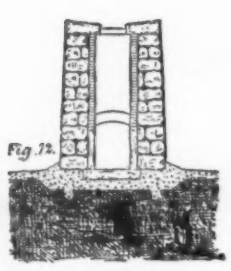


Fig. 12.

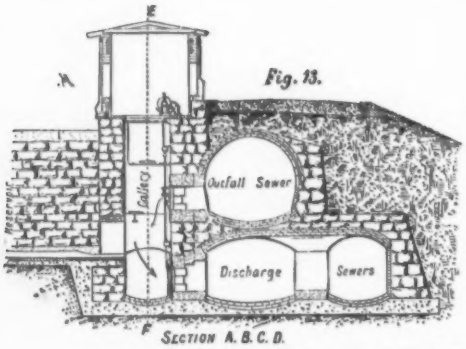


Fig. 13.

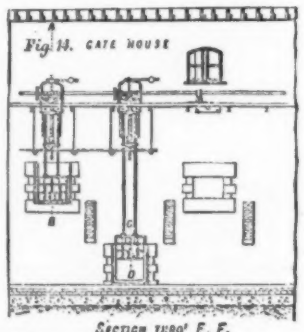


Fig. 14.

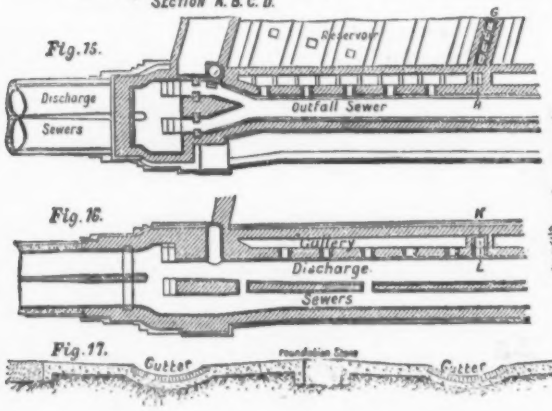


Fig. 15.
Fig. 16.
Fig. 17.

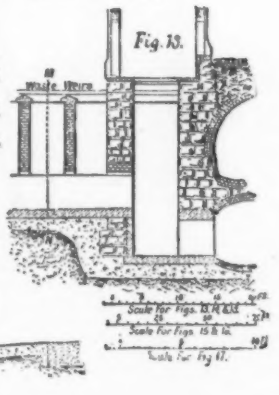


Fig. 18.

THE BOSTON MAIN DRAINAGE SYSTEM.

delivery chambers. The beam is made very short, being 16 ft. 6 in. between end centers, and is connected to the main piston and plunger rods by crossheads and links. The crank-shaft is directly over the main-beam center and a little below the base-level of the cylinder, its journal being in the entablature. Connection from the beam to the crank is from a projecting horn cast on the upper side of the beam, and at such an angle as to secure proper vibration. The diameter of the high-pressure steam cylinder, C, is 25½ in., and of the low-pressure, I, 52 in., with a stroke of 9 ft. The horizontal distance from center to center of cylinders is 15 ft. 2 in., which is the same as from center to center of pumps. The exhaust steam from the high pressure cylinder is passed through reheaters, H, which contain a large number of small brass tubes, through which steam of the boiler pressure circulates, the exhaust steam being outside of the tubes. The distribution of steam is by means of gridiron slide valves, operated by grooved cams placed on a horizontal revolving shaft, which receives its motion by means of gearing from the crank-shaft. The cams impart to the valves a short and rapid movement; the inlet valves of the high-pressure cylinders are also used as cut-off valves, and are automatically controlled by the governor. The governor is so constructed that it will enable the engine to run at any required speed between 5 and 18 revolutions per minute by the simple addition of weights to a scale beam.

The extreme length of the bedplate is 39 ft. 9 in.; the extreme width at the center, abreast the beam pedestals, 12 ft., and at the ends 16 ft. The engine is thus carried, with the exception of the outboard pedestal, within a parallelogram 16 ft. by 40 ft.

The most prominent feature of the engine is the pumps, M M, which are of the single-acting plunger type (Fig. 24), 48 in. in diameter and 9 ft. stroke. There are seven principal parts to each pump, viz., the upper chamber, plunger stuffing-box, delivery valve seating, center piece, lower chamber, inlet pipe, and plunger. The upper chamber is cylindrical in form, 9 ft. 6 in. internal diameter, and 6 ft. 11 in. extreme height. The metal is 1½ in. thick in the body and 2 in. thick in the flanges. The opening for the plunger stuffing box is 4 ft. 9¼ in. diameter, and there is a delivery nozzle, U, 48 in. in diameter, cast on the chamber. The plunger stuffing boxes are 4 ft. 3 in. inside diameter, and 3 ft. 5½ in deep, leaving a packing space of 1½ in. The delivery valve seatings consist of a heavy base 18 in. high, composed of two flanges, united by the frustum of a pyramid 7 ft. 3 in. in diameter at the base, and 6 ft. 7¼ in. in diameter at the top. Upon this base is cast the frustum of a nine-sided pyramid 3 ft. 10 in. high, having a diameter at base of 6 ft. 11½ in., and at the top of 4 ft. 9 in. To this pyramid are bolted nine rectangular valve seats (see Fig. 26), each 3 ft. 6 in. long by 21 in. wide, and arranged for three valves 15 in. by 9½ in., which cover clear openings in the seats 13½ in. by 4½ in. The valves are of rubber, ¾ in. thick, and have wrought-iron back and face plates; they form their own hinges. The lower valve chambers are of cylindrical form externally, about 7 ft. 6 in. in diameter, and 7 ft. 10 in. high. Within these chambers are formed the foot valve seatings, which consist of inverted frustums of a pyramid having six sides, the inscribed diameter being 6 ft. 11½ in. at the top, and 41⅝ in. at the bottom. There are six valve seats, each 6 ft. 4 in. in length by 21 in. in width, and carrying six valves of the same dimensions as previously described for delivery. There are thus in each pump thirty-six suction and twenty-seven delivery valves. The pump under the high pressure cylinder discharges through the pump under the low-pressure cylinder. There is a force main, T, from the latter, 48 in. in diameter, upon which is placed, at a distance of 28 ft. from center of the engine, an air vessel 6 ft. 6 in. in diameter and 10 ft. 2 in. high. The grates or screens for the pumps consist of cast-iron frames and wrought-iron bars, 2 in. by ½ in.; these bars are 2 in. apart. The angle of all the valve seats is 45 deg.

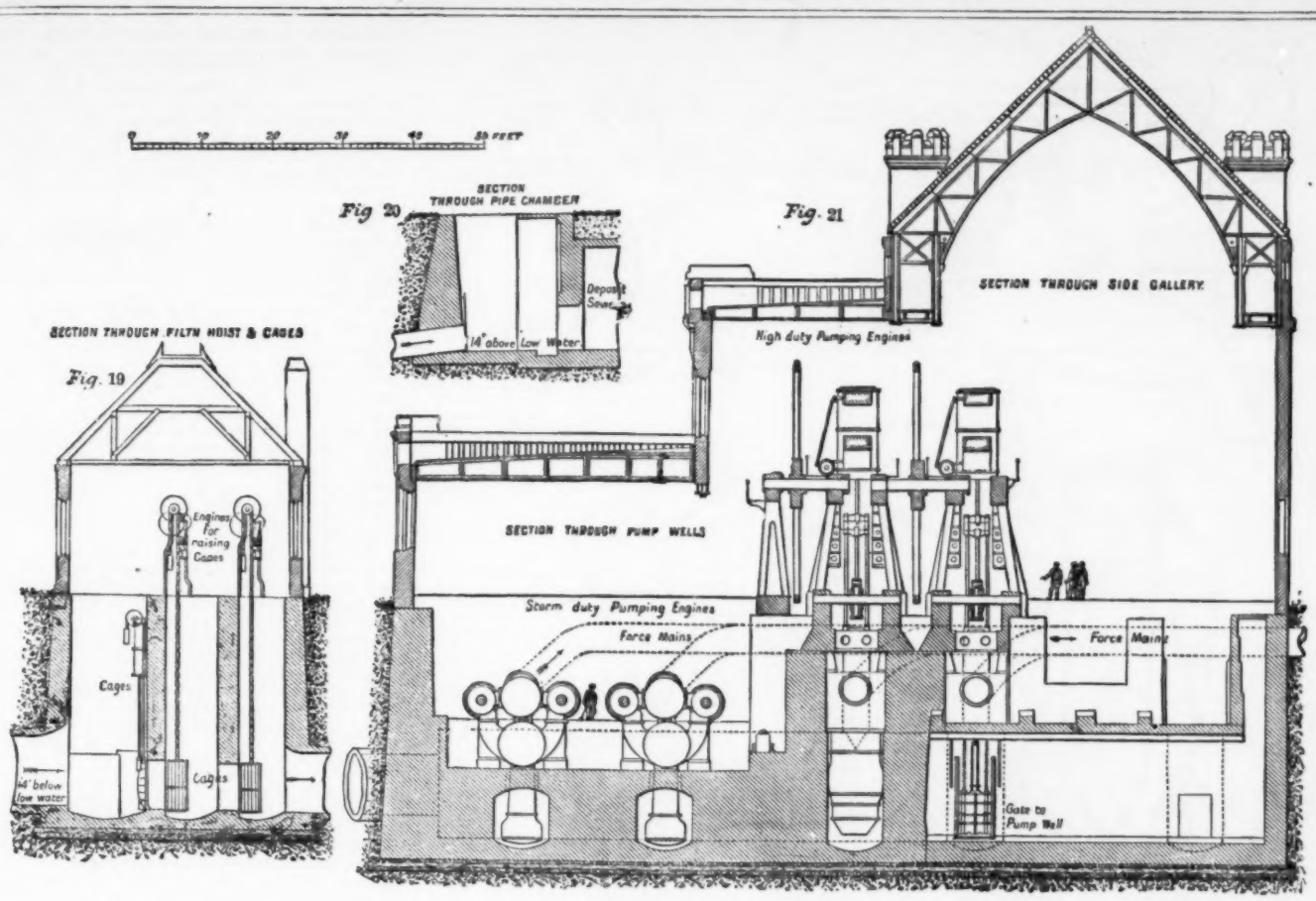
The flywheels are 36 ft. in diameter, and weigh 36 tons each. The shaft is of wrought iron, 17 in. in diameter at journal, and 20 in. diameter in the wheel; the total weight of each engine is over 420 tons, of which, as already stated, the capacity of the high-duty engines is nominally 25,000,000 gallons per twenty-four hours against a maximum head of 43 ft., and with a speed of about 10¾ revolutions per minute. They have, however, been run at a rate which will insure a delivery of 42,000,000 gallons per twenty-four hours, and the performance was such as to leave no doubt that such a delivery could be permanently maintained; 4 per cent. slip has been allowed in these estimates of capacity. The working pressure of steam is 100 lb. per square inch, and with this pressure the number of expansions in the steam cylinders will vary from sixteen to twenty, in accordance with the varying head pumped against.

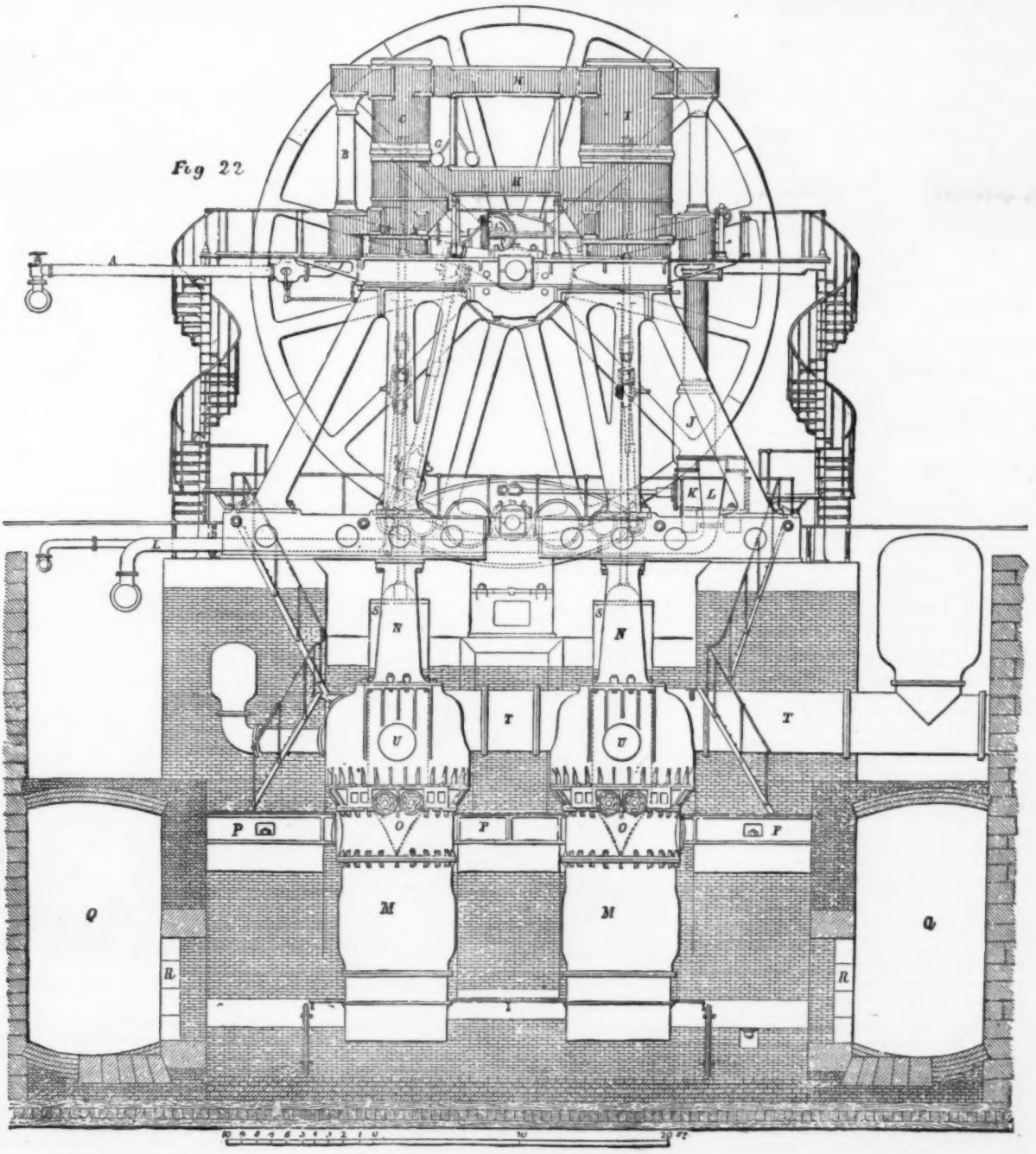
The following particulars are taken from two official trials carried out under varying conditions a few months ago:

Date of trials	March 24, 25.	May 1, 2.
Duration	24 h. 53 m.	24 h. 31½ m.
Revolutions per minute	13·17	13·42
Displacement of pumps per revolution, cub. ft.	226·19	226·19
Total lift, ft.	37·80	42·43
Total weight of coal consumed, lb.	8,307	9,478
Duty developed by engine,	122,500,000	122,400,000
Mean boiler pressure, lb.	99·4	98·6
Total volume of sewage pumped (by plunger displacement) gals. (U. S.)	33,038,000	32,778,000
Total volume of sewage pumped (by actual measurement), gals.	30,224,000	31,256,000
Average slip of pump, p. c.	*8·5	4·6
Indicated horse-power	251·5	290·2
Per cent. of work done by pump	84·66	83·90
Coal burned per indicated horse-power, lb.	1·33	1·35

The low-duty storm engines are of the Worthington duplex type, and have steam cylinders 21 in. in diameter for the high-pressure, and 36 in. in diameter for the low-pressure, by 4 ft. stroke; they operate plungers which are double-acting, 45 in. in diameter; these plungers work in cylinders which are attached to two cylindrical valve chambers having their axes parallel to the plungers, and which are very ingeniously arranged, both for access and efficient action. The valves are of the same construction as those in the high-duty engines. There is a new feature in the steam valve gear, designed by Mr. F. W. Jenkins, of the Worthington Company, which is not of the ordinary Worthington type; instead of the usual rock-shaft motion, they are operated by hydraulic power, through plungers which are driven

* Excess of slip due to torn rubber discharge valves.





SEWAGE PUMPING ENGINES, BOSTON.

Fig. 23

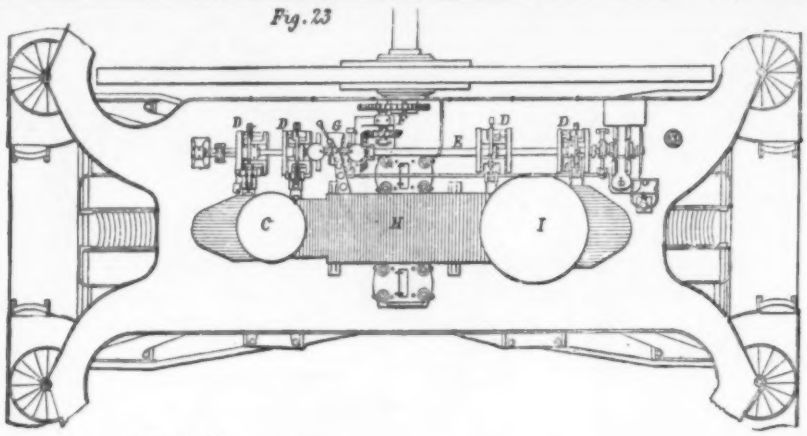


Fig. 24.

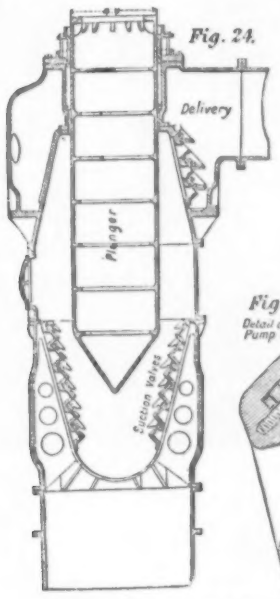


Fig. 25.

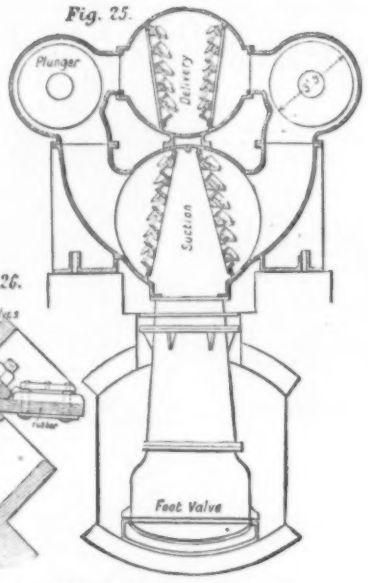
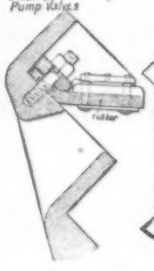


Fig. 26.



SEWAGE PUMPING ENGINES, BOSTON.

by the air-pump levers, and communicate their motion to alternate sides of the pistons attached to the valve stems. Fig. 25 shows the arrangement of the pump valves.

These extensive sewage works are very successful in their operations, and no inconvenience is experienced from the discharge of sewage in the bay. It is gradually carried out to sea, and no traces of it are observable on the shore with the return tide.—*Engineering.*

AN ORIGINAL CANTILEVER BRIDGE.

"THIS bridge at Wangtu is a fine specimen of Himalayan construction wherever a solid roadway is required. It is built entirely on the principle of leverage. Several large trees are felled on each side of the river, and their trunks are laid on either shore, with their narrow ends projecting over the river, and heavy stones laid over the thick ends to increase the counterweight. Cross-bars of wood are then laid over the projecting ends. Thus the first layer is complete. The process is repeated again and again, each layer of trees projecting some feet beyond the last, till the two sets of timbers almost meet in midair, and one more layer crosses both. Then planks laid crosswise form the roadway. The base of the timbers on either side is embedded in solid masonry. Strong railings guard against accident, and an excellent, substantial bridge is thus formed."—*From "In the Himalayas and on the Indian Plains," by C. F. Gordon Cumming.*

WORKING LOW BEDS OF GRAVEL.

WE have had our attention directed to an article which appeared in the *Rocky Mountain News*, published in Denver, Colorado, under date of Nov. 11, relating to the successful operation of a hydraulic mining plant which has recently been placed in position on Clear Creek, near Golden, distant about 13 miles by rail from Denver.

This plant was purchased by Messrs. J. B. Chaffee and George W. Cummings, of Colorado, from the Joshua Hendy Machine Works, of Nos. 39 to 51 Fremont street, this city, through Robert J. Cory, agent at Denver, and comprises two hydraulic giants, one 16 inch hydraulic gravel elevator, and one water lifter, the latter being an auxiliary for pumping purposes to the elevator. The general plan of position and method of operation are shown in the cut herein presented in a somewhat crude manner.

As will be observed by an examination of this sketch, the elevator consists of the lower or entrance sections of heavy, well-ribbed iron pipe, cast from the best iron. These sections are set down say five or six feet below the surface of the bedrock, the necessary excavation having previously been made for its reception. A hydraulic nozzle of proper size is then inserted into the entrance section, fixed in position, and connected by a distributing pipe line with the main supply pipe, ditch, or reservoir. From these entrance sections of the elevator a wrought iron pipe extends upward, at an angle of 45°, to such elevation as it is intended to raise the water, earth, sand, gravel, etc., where it is connected with an upper curved portion of well-ribbed cast iron pipe (flanged together in sections), which discharges into an outer flume or line of sluice boxes constructed in the manner usual in ordinary hydraulic mining.

In addition to the plant, as above described, purchased by Messrs. J. B. Chaffee and G. W. Cummings, their works embrace about 2,100 feet of 18 inch hydraulic pipe, forming the main supply pipe line, with necessary air valves, water gates, and distributing pipe lines to the several appliances.

The appliances forming this plant are simple in their construction, yet strong and durable, and the principles involved are based upon the hydraulic proposition that a volume of water acting under a head or pressure has an a most inconceivable impinging power or force; and experiments have demonstrated that it is as easy to wash earth, sand, gravel, or other material up an ascending plane as to carry the water itself, for it requires as much power to raise a pound of water as it does a pound of the heaviest substance. The greater the pressure, the greater the impact force, and consequently the higher the elevation to which material can be raised, the one being proportionate to the other.

Having given this *rationale* of the principles involved in the construction and the method of operation of hydraulic gravel elevators, we deem it of interest to our mining friends to present some of the facts of the practical operation of the plant referred to.

The volume of water at command is unlimited, and, so far as the work has been conducted, about 1,000 miner's inches were used when the hydraulic giants and elevator were in full play.

The vertical head or pressure of this volume of water is 190 feet from point of delivery at supplying ditch to the point of operations of the elevator on the bedrock; and Mr. George W. Cummings writes to the "Joshua Hendy Machine Works," on the 13th inst., following the article in the *Rocky Mountain News*, thus: "The elevator shaft (in sinking), before the water-lifter arrived, required a windlass at each end, a large pump in the center, all running night and day, with a force of 16 men, to raise the water and sink the shaft. The water-lifter drains the shaft in eight minutes, using the smallest (three-inch) ring in the nozzle. The gravel elevator is a perfect success. I am raising gravel 25 feet with a head of 190 feet, and I will guarantee it to raise 35 feet when I am ready to lower the receiving end."

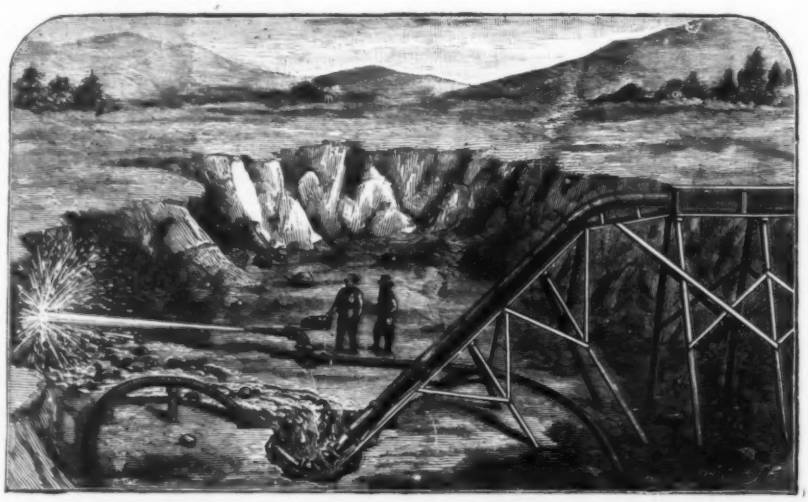
The velocity of the water and gravel through the elevator is almost inconceivable, and a calculation made of the mass of earth, gravel, and sand raised gives as a result the vast quantity of 2,000 cubic yards per day of 10 hours.

The process of washing, which is almost automatic, requiring only the assistance of pipe men to direct the streams from the giants to the gravel bed, which they tear up with incredible force, driving earth, gravel, and bowlders to the elevator entrance, where, by the action of the stream from the fixed elevator nozzle, a suction is produced, the masses of earth and gravel are drawn into the entrance section, and the impinging force of the steam carries everything before it upward and onward to its point of discharge into the outer flume, where the valuable metallic particles are set, led, and retained by riffles, as in usual placer or hydraulic methods, and requiring no more water than in ordinary bedrock sluicing.

Should this experiment, although it cannot even now be called such, prove successful, it will be followed by others of a like character in that and other districts of Colorado, and the result will be a large addition to the output of gold in that State.

When it is considered that the yield of the placers above spoken of is stated to be one dollar per cubic yard, the introduction of several similar hydraulic plants into the well-known rich mining districts of that State would open up vast fields of enterprise, and pour into the channels of commerce streams of golden wealth. Let, therefore, California look to her laurels, and it will be found that the use of these simple and effective machines may destroy the bugbear of the vexing debris problem.

For it will be observed that the plan of operations by the arrangement of the outer flume provides its own dumping ground in the successive stages of workings, and that vast shallow deposits of rich auriferous gravel with low, outlying ground can be opened, new industries fostered, and our State of California made richer within herself.—*Min. and Sci. Press.*



METHOD OF WORKING LOW BEDS OF AURIFEROUS GRAVEL.

HOISTING FROM GREAT DEPTHS.

PROF. J. HRABAK, of Austria, in discussing the means that will have to be adopted to raise ore or coal from depths exceeding 1,000 meters, points out that that depth was reached in 1883, by the Przibram mines, and that several collieries are rapidly approaching it. He shows, says the *Colliery Guardian*, that the ordinary method with ropes of any form whatever will be practically impossible, when the ore has to be raised 1,200 meters, without the use of supplementary engines placed lower down the shaft, and that even these would not enable the ore to be raised from depths greatly exceeding 1,200 meters.

The method that, in principle at least, would enable the ore to be raised from almost any depths is the pneumatic system, which has been in use since 1876 at the Epinac Colliery, in the south of France. The results obtained have been very satisfactory; but as the cost of a pneumatic plant would be greatly in excess of a rope one, it is very improbable that it will come into general use as long as it is found practicable to employ ropes. Having this in view, the author proposes a method by which he considers it will be possible to overcome the difficulties attaching to the ordinary rope arrangements.

He proposes to increase the width of the shaft for half its depth to such an extent that, besides the two principal winding divisions, two secondary ones could also be arranged. Through the principal divisions, the winding would be effected by ropes that reach to the bottom of the shaft, and they would be worked in such a manner that, while half the length of each was wound upon the drum, the other halves would hang down the shaft and counterbalance one another. The ore would be raised by these ropes half the height of the shaft, and would be lifted the remainder of the distance by the secondary ropes. This method of winding would be expensive, on account of the enlargement of the shaft and the necessity for two winding engines. The expense would, however, be compensated for by the winding power being increased by 50 per cent.

STONE PILES IN WASHINGTON TERRITORY.

To the Editor of the Scientific American:

I see in the SCIENTIFIC AMERICAN of October 31, a notice of the "Stone Piles" of Washington Territory, wherein the writer expresses his belief that the mounds were the nests of some kind of aquatic creatures, and refers to an article on the "St. Lawrence Chub Nests" in support of his theory.

I am not acquainted with the locality, "Stone Pile Meadows," to which he refers; but I know something of Mound Prairie, Mima Prairie, and Rock Prairie, all in Thurston County, W. T., and presume that the mounds on those prairie meadows are of the same formation and origin as the ones he names.

I had heard the fish-nest theory advanced by Mr. Thomas Condon, formerly State Geologist, Oregon, and, until I visited Washington Territory, supposed his theory to be correct. But a very slight examination of the mounds upset that belief.

After listening to theories of all kinds, some of which might be called possible, but none of which appeared at all probable, I settled on the ice theory for myself.

In the first place, it must be understood that these prairies are the dry beds of what were once shallow lakes, made dry partly by filling up with wash from the surrounding hills and partly by the wearing away of some obstruction that dammed the water back. That these lakes were shallow is fully proved by the entire bottom being covered with well-washed gravel.

Now let us go back to the earlier ages of the world, to the time when the climate of the northwest coast was much colder than now; when the ice formed to the depth of several inches every winter.

Next we must imagine the end of summer, when, through a very porous soil below and a hot sun above, the bed of the lake was left completely dry. Of course, while the bed of a lake may be, generally speaking, level, yet there will be many little depressions and as many little hillocks, all barely visible above or below the general surface.

After summer come the fall rains; gradually the thirsty soil becomes saturated, and then little by little the water accumulates in the small depressions of the lake bed. Inch by inch the water rises until the whole surface is covered. Then the rains cease, and the frost sets in. One or two months of frost is sufficient; the water is frozen solid to the bottom, and probably several inches below. But spring approaches, the frost ceases, and the rain again comes down in torrents. The flood soon lifts the ice, still gripping its load of gravel, and it goes floating about in broken fragments, that from the deepest places being the thickest, carrying the biggest rocks and the most of them. But the floes cannot go far, because some little rise will catch one and hold it, and another little rise will catch another and hold it, and so on. Now, where each floe is caught and held, it will deposit its load of gravel and sand. So there we have two results—the hole, or depression, where the flow came from is deepened, and the hillock where it lodged is raised, or a new mound started where it was level before. The next year the process is repeated; the deepening places always giving up the most material, and the growing mounds always forcing its delivery as a new contribution to their growth.

How many years the process may have been going on would be hard to guess, perhaps for thousands, until the barriers that confined the water were finally worn away, and channels formed, growing deeper and deeper, until now the beds of the Chehalas and Black rivers are many feet below the present level of the former lake beds.

One strong proof of the ice theory is in the fact that some of the largest rocks, from five to ten pounds in weight, and perhaps larger, are often found at the top of the mounds.

These mounds are of all sizes, from mere swells, barely perceptible, to cones eight or ten feet high. In some places they stand so close together that their bases almost touch, while in other localities they are more sparsely scattered.

The material of which they are formed is the same as that over which they were raised—sand and gravel—ranging in size from the merest speck to ten and probably more pounds in weight. D. I. C.

Lafayette, Oregon, November 11, 1885.

TWO CHIMNEY-PIECES IN WOOD.

THESE fireplaces were designed by Mr. R. A. Briggs, A.R.I.B.A. The drawing-room mantel is for Mr. J. B. Knight of Kensington, and the other is for a dining-room. This latter is furnished with two glazed-fronted lockers or cupboards, while a broad cornice top provides a good shelf for the display of delft and china ware. The grate is a basket one, with a tile-lined fireplace and hearth. For the drawing-room, a hooded arrangement forms the basis of the design, with a hung looking-glass fixed in the center of the front face. On either side of this are two vase brackets with the motto "Loyal en tout" carved on the fascia, below which is hung a deep volume in richly embroidered stuff; a heraldic shield surmounts the glass frame, and the front of the wood is highly decorated in colors.

TWO CHIMNEY PIECES IN WOOD.

THE HUMMEL MONUMENT AT PRESSBURG.

ON the 14th of November, one hundred and seven years ago, the celebrated composer Johannus Nepomuk Hummel was born in Pressburg. He received his first instructions from his father, who was a thorough musician, and was appointed director of the orchestra at a theater in Vienna. At that time young Hummel was seven years of age, and created quite a sensation, attracting the attention of even Mozart, who was so delighted with the child that he took him to his own house to educate him. How often and with what regularity he received lessons from Mozart cannot be ascertained; but as Hummel had to play all the music for Mozart, there is no doubt that he was benefited greatly by being in the company of the great master.

MONUMENT TO THE COMPOSER, HUMMEL.

He remained with Mozart until November, 1788, and then went on an artistic tour lasting six years. Upon his return he was highly recommended by Joseph Haydn, and accepted a position with Prince Esterhazy. In 1811, he returned to Vienna, and occupied himself in giving piano lessons until 1816, and in this year he accepted a position in Stuttgart, which he exchanged for one in Weimar, where he died suddenly, October 17, 1837.

He had acquired for himself a great and celebrated name, not only as a musician, but also as a composer; and at the present day Hummel's works are considered among the finest. As a performing artist he continued in the manner of Mozart, and combined a noble delivery with a brilliant technique, and is the founder of the modern school of virtuosi. He had great talent for improvising, and was no doubt one of the best composers of instrumental music in the nineteenth century.

In 1878, it was decided to raise sufficient money by means of concerts to erect a monument to Hummel at Pressburg. Franz Liszt, Hans von Bülow, Auton Rubinstein, Count Zichy, Joachim, the Meininger Orchestra, Saint Saens, D'Albert, Hummel's great scholar Ferdinand Hiller, and many others contributed to make these concerts a success.

The designs for the monument were prepared by Prof. Victor Tilgner of Pressburg, and the committee made arrangements with him for the execution of his work. A short time ago he delivered his first model, which is represented in the annexed cut, taken from the *Illustrirte Zeitung*. The monument will probably be completed next summer.

This design consists of a Hermes column, the upper part of which is formed by a bust of Hummel, from which wreaths are suspended. On the base a cherub reposes, reading notes from the sheet of music in his hand. Another cherub, at the side of the column, is represented as calling the attention of the first to the bust of the composer. A lyre ornamented with laurel rests against the other side of the column. The bust will be cast in bronze, double life size and the wreaths will be made of copper, fire-gilt. The column, cherubs, base, etc., will be of the finest Carrara marble. The cherubs form a charming group, which is highly creditable to Prof. Tilgner.

MECHANICAL AIDS TO DECORATION.

By A. CURTIS BOND.

MECHANISM in decoration, by which color designs and forms may be indefinitely repeated or multiplied, is always in course of progress; yet it here would seem, with all the varieties of adaptations which we witness, certain defined limits, and in numberless directions of decorative art handiwork, well asserts its superiority. Yet mechanical production itself bears the stamp of intelligent purpose and constructive ingenuity, it being, so to speak, a transfer of handwork, an intermediary between the designing brain and hand, shown in the pattern and the execution. The die of the mould for molten metal and plastic material has either itself to be worked out by hand, or, if obtained by impress of relief work, the relief model has to be carved. The production and duplication of much decorative work by mechanical means is recommended by economy, in some instances by greater uniformity; but in the higher spheres of decoration, the absolute uniformity thus obtained falls far short in value of the direct work of the hand. This is evident in ornamenting in color, walls, and ceilings, if the execution be skillful, as compared with stenciling. The slight variations in the ornament—for the work of the hand never absolutely repeats itself—is itself a charm, as showing greater freedom of execution, and in some instances greater delicacy of touch. Nevertheless, decoration is greatly behooven to the mechanical arts for its diffusion, whether in furniture, structural surfaces, or the ornaments by which interiors are adorned.

One of the greatest novelties promised in mechanical devices, as concerns painting, is a machine consisting of a hand piece, a compressed air chamber, and an air pump, with communicating cup filled with liquid pigment, which enables the artist to throw out a spray which, in the first instance, forms a fine line, and in the second, widens the line to the desired breadth. The skill required in the operation, the proportions to be given to the line, renders the line, which may even be thus shaded at will, something more than mechanical work.

Many devices for facilitating decorative work may be characterized as assistive. They are brought in co-operatively, and are little more than the brush to the painter. The improvement in tools merits notice here. Take, for instance, the wedge-shaped brush so useful for many purposes, previously to the manufacture of which decorative artisans had to wait the wearing down on one side of their flat brushes. Fortunes have been made by smaller devices than these, suggested primarily by individual requirements, and really foreshadowed by the efforts of artificers in their practices or methods to devise means for escaping inconveniences attached to their tools. The tools used for wood carving, and adapted to special purposes and to different scales, have been greatly increased in number of late years. There are mechanical devices which may be regarded as completing the operations of the hand, as when, previously to applying veneer, the ornament adjusted to the pattern and already rubbed down with the veneering hammer, and affixed by glue to paper, is placed between hot boards and pressed with hand screws, which, when the glue is dry, allows the work to come out quite clear from the boards and appear as one piece of veneer, which is then ready for application.

The cowl with its screw clamps comes to the aid of the veneerer to secure a graduated pressure, commencing from the center of the pieces, being an exact counterpart of curved work, and, when flat, employed, like the veneering hammer, for plane surfaces. The heat of the cowl quickly penetrates the thin veneer, making the glue exceedingly fluid, and the pressure applied by the clamps soon expels the greater portion of it, and causes the veneer to bed very closely to the work. Wood carvers, in copying models, are now supplied with a marking or cutting gauge of ingenious construction, by which, when once set to the required dimensions, they can not only give all their markings the relative width, but secure depth of the ground line of the carving and height of relief portion, or rather the excess on their own panel, so as to enable them to cut away freely, instead of timorously dealing their strokes.

The services of the lathe are particularly prominent in decorative woodwork, particularly in hand-turning. In hand-turning the tool is held by the hand, the changes of form made in the wood being dependent on the relative position or angle of the cutting edge. It is the work of an instant only to vary the relative height and angle of a hand tool to the work, converting it from a roughing to a finishing tool, or even to a scraper, which operations are often impracticable with a tool held in a side rest. With the latter the guidance is solely by the eye; with the lathe the delicate sense of feeling is appealed to, so that any variations may be made with absolute accuracy.

In the development of electricity as a motor under the system of storage, much of the preparatory work of the moulder, whether in wood or metals, will doubtless be greatly aided in the future.

Scaffold brackets are among ingenious contributions to the satisfactory execution of exterior house decorative work on walls. This work is necessarily done much better when the artisan has not to balance himself, but obtains a steady platform without unpleasant swaying. The ladder is made with large hooks at top to hang from window sills, and the platform, which is transferable to any of the runs, is fastened by curved hooks attached to an environing bar both to that rung and the rung above.—*Cal. Arch.*

AN ENGLISH FARM HOUSE.

WE give an elevation and plan, from *The Builder*, of a farm house lately erected in Sussex, England, at Vandeane. It presents some interesting suggestions to those who contemplate building in the cottage style.

AN ENGLISH FARM HOUSE.

EARTHENWARE AS A BUILDING MATERIAL.

THERE has been a decided tendency of late to take advantage of the large adaptability offered by terra cotta and other forms of earthenware in architectural applications. It will be remembered that many ancient cities, such as the great Babylon, for instance, were built almost entirely of brick and tiles, though the resources of the ancient potter were much more meager than at present. A larger use of these materials is now being advocated in England. At Brighton and Tunbridge Wells, bricks have been used for paving the street footways, and have proved quite satisfactory. It is considered an advantage that they afford a bit of color in the otherwise monotonous highways. While they are unsuitable for localities where they would be subjected to crushing or jarring under heavy carts and wagons, they are less worn away by the action of water than flagstones, and, being more porous, dry off sooner after a storm. They are cheap, and may be renewed rapidly without interfering with travel. Blue paving bricks are also being advocated for roadways. They are cleanly, and give a secure footing for horses. The cost is considerably below granite, and they would probably wear much better.

As a material for sewers and culverts, brickwork is excellent, and earthenware is admitted to be the best for drains. It is possible that gas and water mains will some time be made of the same material. The glazed surface of earthenware pipes renders them non-absorbent, and, being non-corrosive, they offer no impediment to the passage of water or sewage. Cast iron pipes, it is well known, are liable to be gradually eaten away by the action of gases and acids. Earthenware, on this account, is much preferred for carrying off the wastes from laboratory sinks, since it is free from rust or corrosion. Could it be substituted in water pipes, the supply would be delivered in a purer state and without danger of metallic contamination. Its use in hot water or hot air pipes for heating purposes, and in stoves and furnaces, is considered much more wholesome than iron. Stoves of soapstone or fireclay give a more even heat, and do away with the unhealthy and disagreeable odors which are always noticed in the presence of overheated iron.

It is also suggested that rainwater pipes, instead of being the unsightly affairs they often are at present, might, if manufactured in colored faience, be made to form a pleasing feature in the ornamentation of a building. There are occasional sites, where stone can be quarried in the immediate vicinity and used as an economical building material, but as a rule brick is very much cheaper. A two-brick wall is as strong as one of solid masonry two feet thick. Six inches in space may thus be saved—a matter of some importance where land is very valuable. Bricks absorb more moisture than stone, but they retain it for less time, and there are effective methods of protecting brick walls from dampness, which would be less applicable to stone. Experience in the larger cities has shown that brick possesses a much higher resistance to the destructive influence of fire than any varieties of building stone. At Boston it will be remembered that the solid granite buildings cracked and crumbled in the intense heat before the flames reached them, while those of brick remained comparatively firm.

Another form of earthenware which is very effective artistically, and shares the other advantages of its class, is found in tiles. Hanging against a cheap foundation of ordinary brick, they form a most picturesque covering for external walls. If glazed, they will not absorb moisture. Roofing tiles afford excellent protection against changes of temperature. When chosen of a color to harmonize with the walls of the building, and arranged at a steep pitch on roof and gable, they are very effective. In combination with brick, terra cotta is also becoming deservedly popular as a most durable and artistic building material. As a coping to parapets it possesses many advantages over stone in being free from decay and less affected by the action of storms. In many of our most beautiful modern dwellings, the entire ornamentation is in terra cotta. This is particularly the case in Philadelphia, where the best quality of clay is found within the city limits. Bricks of rich tone, shaped and pressed, when laid in black cement and relieved by copings, dentils, and panels of terra cotta, form some of the most pleasing buildings of the city. But there are bricks *and* bricks. A bad material poorly baked will give wretched results, but, when properly made, there are few more agreeable or durable building materials. English bricks of the last century show a particular indestructibility. Many old Philadelphia residences and not a few Quaker meeting houses in the surrounding country, which were built before the days of the Continental Congress, are still standing and in an excellent state of preservation. Beyond a little wearing away of the mortar, they show no signs of deterioration, while they have already witnessed the rise and fall of several generations of less substantial structures.

MASONRY AND BRICKWORK IN FIRES.

IN the whole range of building materials there is perhaps none so unsuited for resisting fire as that most commonly in use—stone. It is true that, if embedded in cement or in thoroughly good mortar of lime and sand, it will resist for a considerable time heat gradually applied; but even in such a case it will become calcined, and will crumble to so great an extent as to be unable to carry a load afterward. In the case of any sudden change of temperature, either from cold to heat or from heat to cold, it cracks instantly without notice, not only leaving a passage for smoke and flame, but in many instances causing the wall to fall. Stone may, however, be used with a certain amount of safety for external walls, but even for this purpose it is very much inferior to bricks. Bad mortar is frequently a cause of heavy loss; it has no adhesive power, and, consequently, fails to bind the other materials in such a way as to prevent buckling. A great quantity of the mortar used in this country during the last fifty years is but little better than road mud, which, though in itself well suited to resist fire, is wanting in the most essential qualities for combining with other materials. Really good mortar becomes in course of time as hard as the bricks or stones, and good cement becomes much harder. In fact, when a hole has to be cut in a wall of bricks laid in sound cement, it is generally necessary to cut through the bricks, as the tools in ordinary use for such purposes cannot cut through the cement.—*E. M. Shaw, in The Architect.*

A COMPANY for the manufacture of fireproof lumber is in process of organization at Chicago. The capital is to be $100,000. The desirableness of the object is evident at a glance. This scheme is a significant indication of the extent to which the importance and necessity of the prevention of fires is occupying thinking and inventive minds.

Lumber that can be rendered to a good degree fireproof, at a reasonable cost, would certainly be in great demand. We wish the Chicago enterprise much success.

HOUSE AT ST. GEORGE'S HILLS, WEYBRIDGE.

THIS house is being built among the pine woods on the newly opened up St. George's Hills Estate, which makes Weybridge one of the most favorite neighborhoods within twenty miles of London. The wall facings are of orange-red Bracknell bricks and red tile hangings, the half timbered gables and tympanum over porch being filled in with cement ornament in relief, and colored with Indian red and yellow. The roof is covered with brown Broseley tiles. The entrance hall, staircase hall, and staircase landing are to be handsomely fitted in the Jacobean style, and the sanitary work is under the superintendence of Professor Corfield, of London. The architect is Mr. W. H. Seth-Smith, M.S.A., of 46 Lincoln's Inn Fields, London, and the builder, Mr. S. Woods, of Weybridge.—*Building News.*

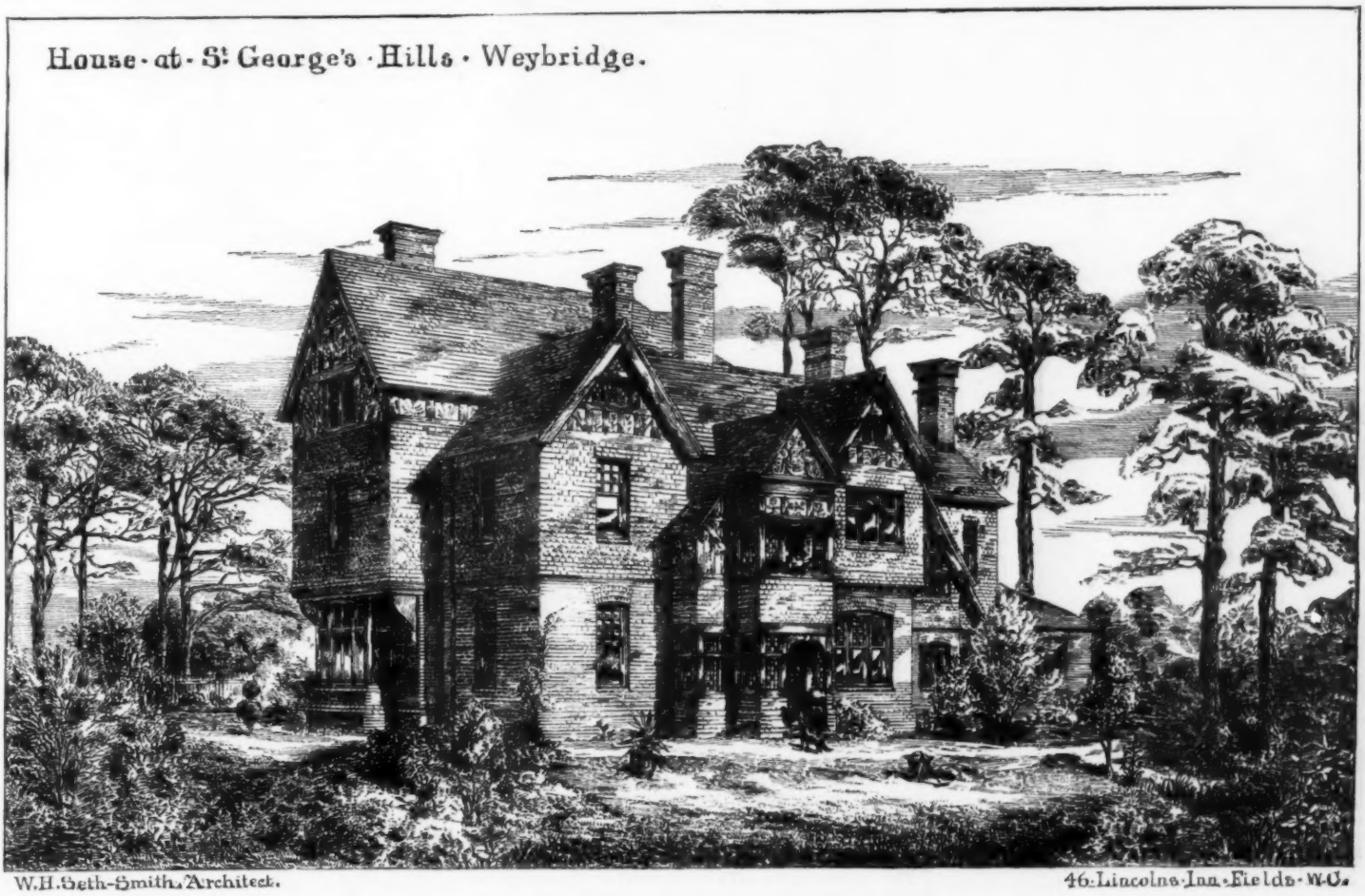
BUILDERS' QUANTITIES.

THERE is generally a considerable difference to be noticed between an estimate prepared by a builder from a set of drawings and a specification and one which is based upon bills of quantities prepared by a regular surveyor. It is often assumed that a builder can sail nearer to the wind than a surveyor; that he is not under the same necessity for allowing margins of safety, and that, in fact, as he makes any omissions at his own risk, he knows how to compensate himself for such lapses of forethought. Hence, in small works, when an estimate has been accepted on a builder's own quantities, the architect is more than usually on his guard against making allowances for extras. When there is a disagreement in such cases, the amount in dispute is often so trifling that the builder ends by yielding the point and accepting the architect's award. If the architect be a fair-minded man, he will endeavor to adjudicate impartially between the builder and the building owner, allowing the interests of neither to gain any undue ascendency. This, however, is an extremely difficult thing to do. Setting aside the fact that an architect's own interests are mainly identical with those of his client—a fact which, it is fair to say, does not influence the conduct of most professional men—how does the question usually present itself to the mind of an architect? On the one hand, there is the client, a man unversed in the technicalities of building, and therefore completely at the mercy of those acquainted with all its mysteries. On the other hand is the builder, with his own special, practical knowledge, which on some points may exceed that of the architect, and with one object before him—that of carrying on his business with the greatest amount of profit to himself. It is then assumed at once that the client alone stands in need of protection; and so it often happens that an architect becomes virtually his client's advocate, instead of maintaining a judicial attitude between him and the builder.

When a builder commences making an estimate without a previously prepared bill of quantities, he has an amount of labor thrown upon him for which he can claim no remuneration, and which, in a competition, may prove utterly unfruitful. In taking off quantities, although he will probably adopt more simple and rough and ready methods than would be found convenient for a surveyor, his task becomes really more complex. Instead of taking off a number of dimensions, to be subsequently squared or cubed, abstracted, and brought into bill, he may be seen examining the drawings with knitted brows, going through mental calculations, and occasionally jotting down rough notes. He "lumps" many of his items, considering in his mind the quantity of materials required, the markets where they can be obtained, the cost of carriage, the amount and quality of labor involved, and the profit for which it will be worth his while to undertake the work. Such methods of procedure, so far from being haphazard, demand the exercise of more thought, and bring into play a larger amount of practical knowledge, than is generally realized. The items which are "lumped" in a surveyor's bill require an equal amount of careful consideration in pricing, but these items are comparatively few.

In estimating the cost of carving and other ornamental work, the builder often runs considerable risk, unless there is a plentiful supply of large-scale details to form the basis of his estimate, or unless he is thoroughly familiar with the style of work which the architect is in the habit of carrying out. In an open competition, when the lowest tender is to be accepted, there is little doubt that differences between estimates are often largely due to vague drawings or the absence of provisional sums for ornamental work in the specification. Marginal sketches in the latter are extremely useful to an estimator, and might be introduced more extensively with advantage, especially in these days of rapid work, when it often happens that there is not time to draw many details before the contract is signed. Architects are usually ready enough to furnish a builder with all the information they can command, and to afford him every facility in preparing his estimate; but time rarely permits of this being done in a thoroughly satisfactory manner to all concerned. Sometimes a builder is allowed two days in which to estimate the cost of a work. He cannot be expected, under such circumstances, to take off quantities, in any true sense of the words, and thus finds himself driven to adopt expedients which only very sound knowledge can make reliable. An inexperienced man who secures a contract in a competition may well doubt if he has not engaged in an unprofitable undertaking, and may even come to envy those who have given time and thought to the preparation of estimates which have not been accepted.

When an architect is carrying out a work for which the estimate is based upon builders' quantities, he should bear in mind such circumstances as we have endeavored to delineate. As a matter of fact, such estimates often come out much cheaper than those which are made from bills of quantities supplied by a surveyor. In some cases, builders have been known to make little or no profit upon the original contract, and have even sustained losses over extras and omissions. In these days of bad trade, it is indeed hard to be presented with the alternative of standing idle or of working to no advantage, and every consideration ought to be shown, in carrying out the details of a work, to those whose toils are but too seldom adequately rewarded.—*Build. and Eng. Times.*



EDUCATION IN THE UNITED STATES.

THE pride taken in popular education in the United States makes any digest of their experience valuable; and education, as carried on in their cities, the subject of a recent "Circular of Information" from the Bureau of Education, is necessarily the branch of it most interesting in our crowded island. Dr. Philbrick, the writer of it, has been, in Boston, a most successful school superintendent, an officer who undertakes the active duties of both School Board and Government Inspector, and one without whose services cities are here said to be behind the times. The uncertainty of a good choice of members for a school board by popular election in the United States makes this office the more important; women having, as a rule, declined to counteract corrupt votes by their own.

Every branch of education is treated upon here. Technical instruction, both as provided in Paris and in the United States, is largely and systematically considered—from the shape it takes in the school, where it simply replaces the gymnasium to boys over thirteen years of age, to the apprentice school, which really attempts to supersede the worn out system from which it gets it name by a more scientific and intelligent teaching of a few trades, among which building in its various branches, necessarily so important in a new country, is always one chosen. School museums are recommended, both of natural history and of technology; the decoration also of schoolrooms with statuary, etc., now provided for the purpose at low prices, a list of which is appended.

The rules to be observed in building are a digest of both European and American experience, valuable to every one concerned with the architecture of schools of any class; and we may just note Dr. Philbrick's conclusions—that increased centralization and permanency are found desirable; that *speaking* French or German is unnecessary to ninety per cent of secondary scholars; and that high school education is bad for girls. "Free and uniform" is Dr. Philbrick's ideal. He believes that the work of elementary schools can be so revised that the higher subjects will be a simple continuation of the lower, so that a complete elementary course shall be just the same as the first few years of a university education. Higher stages are never to be commenced till after the age of fourteen. Free high schools, "the most truly democratic of all our institutions," are being used by youths who go back to farm work, contending that in no way does a classical education unfit a man for manual labor and attending meetings of "old boys," whose common interest in the school helps to obliterate social distinctions.

Such schools are to be provided for the mechanic to carry on his studies therein in the evening; while for for higher students manual labor, especially the use of carpenters' tools, is to replace the gymnasium, and be pursued afterward in evening technical schools; and thus study and labor will complement each other, and the daily toil of the poor man is raised to the level of the rich man's recreation. Military and fire drill are to be taught, and replace out-door games. We fear that an elementary course complete in itself and different from university rudiments, although perpetuating class distinctions, will probably be a necessary evil for some time yet, and also that paralysis for lack of competition must be incurred where pupils are required to attend the school in their own district of their own city—thus necessitating uniformity of books for the sake of families removing.—*Nature.*

OUTWITTING OUR HEALTH OFFICERS.

THE small-pox epidemic at Montreal rendered it expedient that railroad passengers from that city should be examined as to their sanitary condition, and if they have been vaccinated. The Springfield, Mass., *Republican* is credited with the story of a Vermont woman who, having occasion to travel on a Montreal train, determined to outwit the sanitary inspector by making him think that she had been recently vaccinated. Accordingly, she sewed a button to the inner side of her sleeve, at the usual site of vaccination, and, when the inspector asked her to show her arm, answered that it was not necessary, for he could "feel the scab." The device is said to have succeeded.

AUTOMATIC POSTAL-CARD AND ENVELOPE DISTRIBUTER.

IT would be a great public convenience if each of us had at his disposal, away from home, night and day, at all hours, and everywhere, postal cards, and stamped envelopes containing a sheet of letter paper. In fact, it would be expedient to render depositories of these objects as numerous as letter boxes. But we cannot think of obtaining the multiplicity desirable by means of deliveries that are always open, since the expense of location, help, light, etc., would be out of all proportion to the income derived therefrom.

Messrs. Sandeman & Everitt have very happily solved the problem through an automatic distribution, their apparatus requiring the presence of 20 employes to maneuver it. One or two visits per day are sufficient for keeping the distributer full; the rest is an affair of the public. The arrangement, which is shown in the engraving, is called the "Postal Card and Stamped Envelope Public Supply."

The apparatus consists of a cast-iron box 18 inches long, 12 inches wide, and 14 inches high, having a sloping cover upon which writing may be done. Behind it there is a frame that contains printed directions telling the purchaser how to operate. This box is divided into two compartments. The one to the left contains a package of postal cards, and beneath the latter there is a drawer whose cavity is capable of containing one card, and one only. These cards are a little thicker than ordinary postal cards. The drawer, through a suitable mechanism, remains closed, and cannot be drawn out; but, if a penny be dropped through a slit in the cover, it becomes unfastened, and, as it is pulled out, brings with it a postal card—the last one at the bottom of the package. When the drawer is shoved back it becomes locked again, and is ready to deliver another card upon the deposit of another coin, and so on, until the cards are exhausted. At this moment, through the removal of the last card, a spring closes the slit, so that a person cannot drop in any more

AUTOMATIC POSTAL CARD BOX.

coins, and at the same time displays the inscription "Empty," thus giving the reason for the obstruction. In the compartment to the right is the package of stamped envelopes. This is maneuvered in exactly the same way that the other is; but, instead of one slit for one penny, there are two slits for a penny each. When the money box on either side has received its cash, the mechanism closes the slits until the goods paid for have been removed. This apparatus is placed in all the railway stations of London. It is so arranged as to be under the eye of the station employes. Although the slits permit of introducing coins of definite dimensions only, and the mechanism works only under the action of a given weight, cases have occurred where certain unscrupulous and very ingenious persons have put pieces of lead of exactly the weight of a penny into the box; but such cases have been very rare. Moreover, the risk is not much, since each compartment contains but 25 cards or envelopes. It would be easy, were it needed, to add an automatic electric bell, the ringing of which, by attracting the attention of passers-by, would trouble guilty consciences. The box costs about thirty dollars. There are nearly a hundred placed in the London stations and cafes. They have proved a great success, both from the standpoints of curiosity and utility. In England all places are closed on Sunday, and the only way to get a postal card or stamped envelope is to have recourse to the supply box. We should not be surprised to see this ingenious vender before long supplying small objects of regular prices and dimensions, such as boxes of matches, cigars, omnibus tickets, etc.—*La Nature.*

PROF. PALMIERI'S UDOMETER AND ANEMOMETROGRAPH.*

IN continuation of a preceding study, and to close the already long list of apparatus in use at the Vesuvius Observatory, I shall confine myself to a description of the principal parts of two of the instruments that it remained for me to examine—a udometer and an anemometer with electric registering device.

*P. Marcillac, in *La Lumiere Electrique.*

The Udometer.—This consists of a bucket wheel connected directly by a metallic tube with a rain collector properly exposed to the open air, and of known superficies. The ten spokes of the wheel, R, consist of so many tubes that communicate respectively, through one extremity, with one of the ten buckets, *a*, and through the other with a hollow cylindrical hub, C. This latter revolves with slight friction upon a horizontal tube, which serves as an axle, and which contains in the center a single aperture, in front of which each of the hollow spokes presents itself in succession. By reason of this arrangement the water from the rain collector follows the tube, T, the axle, A, a spoke, *r*, and fills one of the buckets, *a*. As the weight of the liquid breaks the equilibrium, the wheel revolves, the bucket empties, a second spoke presents itself opposite the aperture, a second bucket fills, and so on. The surface of the collecting funnel is such that one of the buckets fills for each millimeter of water collected. The quantity of rain that has fallen, its duration, etc., is then easily known. Every time one of the buckets descends and empties, it comes into contact with a system of

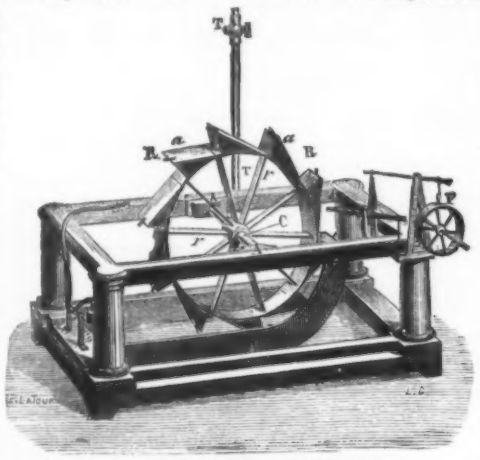


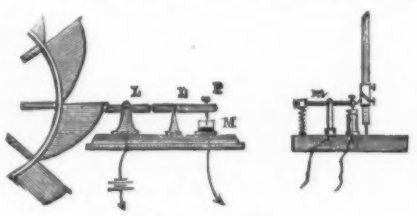
FIG. 1.—PALMIERI'S UDOMETER.

levers which actuate a pencil-holder, P, and the pencil then forms a line upon a paper band moved with regularity by any sort of a motor whatever. As this band is divided, it suffices to read the number of dashes in order to know what was the number of contacts in a given time, and consequently the number of buckets that were successively filled.

To the left of the figure will be seen a very simple device to prevent the wheel from revolving backward, and to cause the spokes to present themselves regularly in front of the aperture in the axle. The water that falls from the buckets is received in a vessel beneath, and from thence runs into a graduated tube which permits of controlling the indications given by the udometer. In certain stations it is not convenient to place the udometer near the registering devices, since, if the building has several stories, this would oblige the observer to go up stairs frequently to examine the apparatus.

I have remedied this as follows: For the system of levers and the paper wheel I substitute a double rod formed of paraffined wood oscillating in a jaw after the manner of a Morse key and terminating on one side in a beveled end, and on the other in a platinum point, *p* (Fig. 2). A strip of metal set into the wood leads the pile current to the platinum point. This point grazes the convex surface of some mercury in a cup, M, which is connected with a receiver of the Morse kind. Every descent of the buckets actuates the levers, L, closes the circuit, and moves the armature of the receiver. The registering is effected with the same regularity, and the advantage is obtained that the receiver can be placed in the observer's office at any desired distance from the udometer. Upon maneuvering the starting lever at the beginning of a shower, one can observe the intensity and duration of the rain without discommoding himself.

The Anemometer.—This apparatus comprises a double transmitter and a double receiver. It registers both the velocity and direction of the wind (Fig. 3). The first transmitter is a Robinson wind-wheel, whose vertical shaft is provided beneath with a sleeve which, at every revolution of the wheel, closes the circuit of a pile by slightly pressing a key, *m*, provided with a platinum point that grazes the surface of some mercury. Further along we shall see how the contacts thus obtained are registered. The second transmitter, which is designed to show the direction of the wind, consists of a metallic four-sided cage. Each side consists of the open base of a truncated cone, whose apex



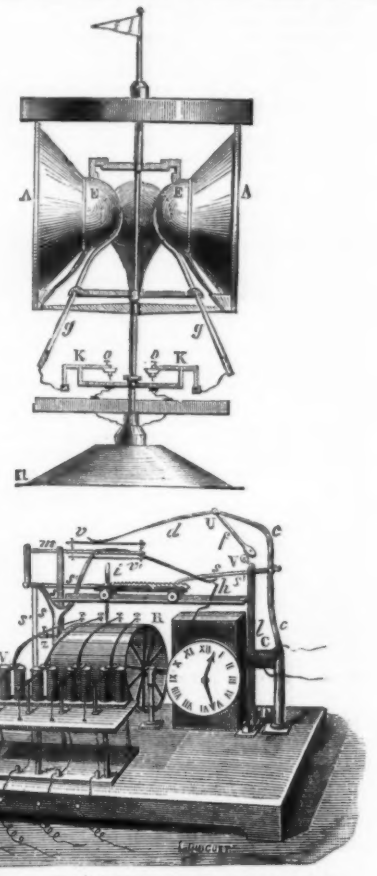
FIGS. 2 AND 3.

is closed by a hemisphere, E, which is provided with a lever, *g*, and is so balanced as to oscillate under the slightest breeze. To prevent the introduction of rain or dust, a tubular appendage is added to each hemisphere which carries the liquid, etc., off.

Under the stress of the wind, one of the buckets, E, oscillates, and in this motion the rod, *g*, carries along the bent lever, *k*; an electric contact is established at O, and the current actuates the receiver described below. As the cage is set in the direction of the cardinal points, it will evidently be known from what direction the wind proceeds, according as one or the other of the levers is in contact. Moreover, if the wind is blowing from an intermediate quarter, from the N. W., for example, it will, since it must strike two faces of the cage obliquely, actuate two of the hemispheres, and consequently two of the levers, and the registering will be done as in the first case.

In this way, eight directions of the wind can be registered, and, with an eight-sided cage and analogous arrangements, sixteen might be registered.

Velocity Receiver.—A bevel gearing actuated by clockwork carries along with a regular motion a light drum, R, which carries a band of paper divided into equal parts that correspond to the horary zones. Above this drum there moves from left to right a pencil-holder supported by a four-wheeled carriage. The pencil is kept lifted at some distance from the paper by means of a spiral spring. The carriage runs along a double rail. Alongside the clock to the right of the drum there is a column which supports both an electromagnet, C, and a copper arm, *cc*, at the end of which oscillates (at U) a bent lever, *df*. The armature of the electro consists of a large rod, *ll*, movable at T, and terminating at the other end, V, in a small wheel.



FIGS. 4 AND 5.—PALMIERI'S ANEMOMETER.

Slightly beneath the latter the armature carries two long hooks, SS', which are balanced by two balls of metal, and whose extremities engage with the teeth of a double rack that forms part of the pencil carriage. It should be remarked that the carriage, which is drawn from left to right by the hooks, SS', is pulled in an opposite direction by two small counterpoises fixed to the wires, *ss* and *s's'*. Finally, beneath the carriage and pencil there is a parallelogram, VV, which is supported by a rod, *m*, and is capable of being depressed or raised under the action of two spiral springs.

At every emission of the current, that is, at every revolution of the wind-wheel, the electro attracts its armature. This latter carries along the hooks, SS, and the wheel, V, at the same time rolls over the base of the lever, *df*. It results that the hooks cause the carriage to advance one division, while at the same

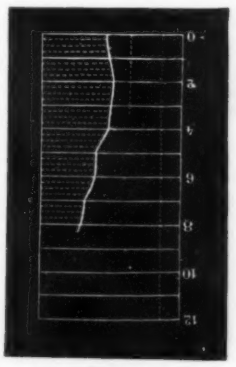


FIG. 6.

time the lever, *df*, descends upon the parallelogram. This latter descending, and pressing in turn the upper part of the pencil, obliges the latter to make a dot upon the paper. The pencil will thus form upon the cylinder a line of dots that will be equally spaced, whatever be the velocity of the wind-wheel. If, for example, the motion of the carriage lasts one minute, it will be known how many revolutions the wind-wheel has made, and consequently what the velocity of the wind is.

This interval of time having passed, it is necessary to push the carriage back and begin a new row of dots; this is here done automatically. In fact, an eccentric moved by the clockwork shifts an arm, *p h*, at regular

intervals, and this in turn lifts the hooks, S S, and a lever, *s s*, that breaks or establishes the electric currents of the wind-wheel. The carriage, being freed by the hooks and pulled by the weights, quickly runs back to the point where the hooks, S S, fall and engage again with the last teeth of the rack. At the end of twenty-four hours, on unwinding the paper band, we find a curve of the wind's velocities (Fig. 6). If it be desired, endless paper may be used; but in order to force the observer's attention, Prof. Palmieri prefers to renew the band every day.

Receiver for Direction of the Wind.—Opposite the drum, R, cited above, there are four vertical electro-magnets, V' V, that attract as many armatures, to which are fixed four bent arms terminating in pencil-holders. Each of these electros communicates with one of the four contact levers, K K, of the cage above described. When one of the hemispheres, E, is struck by the wind, it turns and carries along its annex rod, *g*. This latter moves the lever, K, and the circuit of a pile is closed at O through the descent of a platinum point into a mercury cup. The current goes from the latter to the electro that corresponds to the hemisphere struck by the wind, and the direction of which has been previously determined.

The armature is attracted, and the pencil that it carries descends, and leaves a trace upon the paper as long as the contact keeps up. Let us suppose a wind from an intermediate quarter, say N.W.; two hemispheres will be moved, two electros will be actuated, and two simultaneous lines will be left by the pencils. Moreover, if one of the hemispheres be the more strongly struck, we shall remark that, as a consequence of a better contact, one of the two lines is the more prominent. We shall thus have, not only the resultant direction of the component winds, but the relative value of each of them. If, for example, a N.N.E. wind be received, the line N. will be very strong, while E., on the contrary, will be fainter. It becomes very easy to distinguish these, and, as may be seen, it is possible with four electros to obtain indications for sixteen directions, principal or secondary.

The proper band on the drum, R, may serve for registering the quantity of rain that falls, as well as for registering the velocity and direction of the wind. In this way, with a small, easily inspected apparatus, we can collect the three principal data that it is useful to have in a meteorological station of some size.

COSTIESCO'S FIELD QUADRANT.

THE annexed figure represents a small, portable, copper, topographical instrument designed to serve in the operations of planimetry and altimetry, and to be employed as a cross, as a goniometer, as a compass, as an eclimeter, and as a leveling alidade. Besides, it will give directly, and in a simple manner, the horizontal distances and differences in level with respect to a base of 100 meters.

There are two forms of the instrument, one of them with sight vanes and the other with a telescope, the latter being the one represented herewith. The sight vanes are from 1½ to 1¾ inches in height, and each of them contains three very small apertures and a rectangular slit provided with cross hairs. In order to facilitate sighting at long distances, all the vanes have a slit in their upper edge in the direction of their axis. The telescope is a very clear, achromatic, astronomical one, 16 inches in length, with an objective 0·8 inch in diameter, magnifying twelve times. It is mounted upon the alidade, which is moved by means of two uprights about two inches in height, and carries, engraved upon glass, two lines crossing each other at right angles, for sighting, and two micrometer lines for the service of the stadios. Its optical axis is in the vertical plane that passes through the index, the vernier zeros, and the center of the instrument. Above its horizontal axis, which is rectifiable, it is provided with a spherical level, which is set into the re-enforce that carries the two pivots.

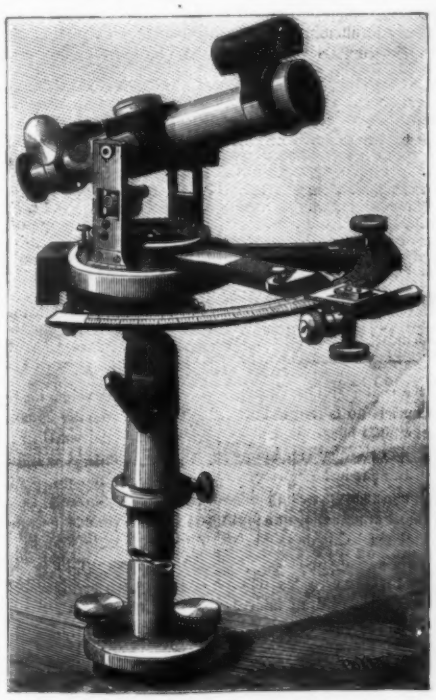
In such models there is a collimator tube that serves as a datum sight, and, in both, the fixed alidade carries a spherical level for vertical planes and a longitudinal level with two faces to serve in vertical planes in both up and down grades. The movable alidade carries a compass 2¼ inches in diameter, whose center coincides with that of the instrument. The length of the alidades from their crossing point to their extremities is 4 inches. The width varies from 0·3 to 0·6 of an inch.

The stand is provided with a ball and socket joint that allows the instrument to be given every motion and position possible in the two planes. The stand takes apart in three pieces for ease of carriage, and the instrument is packed in a leather covered box which may be slung over the shoulder or fastened to a saddle. A small lens placed in the box facilitates the readings of the divisions, and a bobbin with a 32 foot tape, divided into meters, decimeters, and centimeters, serves for measuring the base line.

From this brief description, and an examination of the figure, it is easy to see how the apparatus is to be employed for the different purposes for which it is intended. Such, in short, is Colonel Costiesco's instrument, which all the commissions, civil and military, that have been appointed to examine, have been unanimous in declaring to be a very practical one for topographical operations in the two planes, and very useful for military surveys and reconnaissances.—*La Nature.*

BIMETALLIC STORAGE BATTERIES.

MANY articles have appeared from time to time, describing and giving interesting information concerning the Plante secondary battery and its numerous modifications. It is not the intention of the writer to touch upon such, except incidentally, while comparing another form, perhaps quite as interesting and instructive, namely, that type in which the electrodes consist of two different metals in an electrolytic fluid, which is a soluble salt of one of such metals, like the so-called zinc-lead accumulators, with electrodes of zinc and lead in sulphate of zinc, and the copper-lead accumulators, with electrodes of copper and lead in sulphate of copper. In this class the zinc and copper are alternately deposited and dissolved, and the lead oxidized to the peroxide, and reduced to spongy lead. The history of such batteries, in their primary form, dates back many years. In 1826, Nobili deposited peroxide of lead upon platinum plates by the electrolysis of a solution of acetate of lead; and in 1837, Professor Schönbein of Basle announced that such plates possessed highly electro-negative qualities. This discovery laid the foundation for numerous powerful although impracticable galvanic batteries, and Grove, in 1839, seems to have been the first to anticipate them, as is shown by an article by him in the London *Philosophical Magazine*, series 3, vol. xv., page 290. To quote his words, "There is still, however, another imaginary voltaic circle (I am tired of iterating the word combination), which would be superior to any of these. It is one of three elements; two metals or substances having the electrial properties of the metals, and an electrolyte. Of these two substances, the positive should be analogous to zinc, but the negative should possess a strong affinity for the cation of the electrolyte and unite energetically with it, as it separates in a nascent state, or rather should of itself be able to tear it from its associated anion. Such a substance is, I think I may say, at present unknown; the nearest illustration I can give is mercury when associated with zinc and a cuprous solution. The peroxide of lead of Professor Schönbein with zinc and an electrolyte may serve as another. In a circuit of this description, we should have actually the sum of the affinities instead of their difference, and I can conceive no more powerful hydro-electric arrangement." De la Rive soon after, acting under this suggestion, experimented with the peroxides of lead and manganese, and constructed a battery in which peroxide of lead moistened with dilute sulphuric acid, and surrounding a plate of platinum, acted as the negative, and zinc in dilute acid the positive plate. He obtained powerful results from this arrangement. Grove, soon after the invention of his gas battery in 1842, also experimented with the oxides of metals. In 1843, Wheatstone designed a battery in which the negative plate consisted of platinum, with peroxide of lead deposited upon its surface (by the electrolysis of a solution of acetate of lead), and the positive plate of potassium amalgam. This is the most



COL. COSTIESCO'S FIELD QUADRANT.

energetic battery ever tried, but extremely impracticable and expensive. Joule also used the peroxide of lead in the same manner, but the positive plate was amalgamated zinc in caustic potash. He obtained an electromotive force of 2·54 volts. The use of platinum was the great drawback, besides which, as soon as the peroxide of lead was reduced, it had to be renewed, as did also the zinc when consumed. This style of battery died out, with the exception of the well-known Leclanche cell, similar in nature, but containing peroxide of manganese instead of peroxide of lead. The cheap cost of producing electricity by the dynamo machine showed the great importance of storing it, if possible, and secondary batteries were brought to the front. Probably the most important use to which they can be put, is the regulating of the varying currents of electricity produced by the irregular motion of gas engines while actuating dynamo machines, thereby making eletric lighting a commercial success.

This case calls for a durable battery; and weight, except in a few instances, is of minor importance. Let us for a moment look at the attempts made to reduce the weight in the Planté forms.

Siemens deposited oxide of lead in the pores of carbon plates by repeatedly soaking them in acetate of lead, and driving off the acid by heat. These plates were then charged by the electrolysis of dilute sulphuric acid. They were, however, unsuccessful, and, in the opinion of the writer, on account of excessive local action while the battery was at rest. Upon one of the electrodes there is a formation of spongy lead in contact with carbon, and as the plate is in sulphuric acid, sulphate of lead is formed, the resistance thereby increasing, and the electromotive force decreasing. Upon the other electrode there is peroxide of lead in contact with carbon, and on account of the higher electro negative character of the former, disintegration of the carbon plate ensues. The same can be said of later batteries in which spongy lead and peroxide are deposited upon carbon plates by the electrolysis of a solution of the basic acetate of lead. Dr. Kalischer has seen the importance of preserving the substance or metal beneath the coating of peroxide of lead, and deposits it upon iron from the solution of nitrate of lead. The passive iron is not attacked by the strong nitric acid. Time will show if the amalgamated lead is attacked by the liberated acid, as it will also show if there is not some local action between the peroxide and iron while the battery is at rest. There will also be greatly varying battery resistance, as at the beginning of discharge there is the good-conducting nitric acid, which gradually becomes resistant as nitrate of lead is formed. Faure's, and similar batteries, cannot be said to have been successful, and principally on account of the same trouble—local action. In these batteries, we have, after charging, highly electronegative peroxide of lead in loose contact with lead, in consequence of which there is a formation of sulphate of lead, and in time, by recharging, disintegration of the lead plate. No doubt, by increasing the surface of the lead plates and decreasing the thickness of the layer of oxide, one trouble (the increased resistance by this formation of sulphate of lead) would partially disappear; but then we should have only a poor form of the Planté battery, with its great weight and without the advantage of having a firm, compact layer of the peroxide, which prevents to a certain extent local action, as the acid cannot penetrate as readily through such a coating to the lead surface. The proper electrode would appear to be one upon which a thick layer of active material could be quickly formed (as that of Messrs. Parker and Elwell), and the thickness of the metal should be such that, after the electrolytic penetrating action should have reached its limit, there would still be solid metal to spare. There is but little doubt but that this action mentioned above becomes less and less as the coating is formed, and in time becomes trifling. At the same time, however, the metal should be as pure as possible, and mechanical means should be used such that any detached particle of oxide would by its own natural expansion be forced more tightly again its own layer. M. Emile Reynier is now perfecting an electrode partially fulfilling the latter condition. By these means, the life of the battery will no doubt be considerably lengthened. The object of the foregoing is principally to show that, for decreased weight, the negative or peroxidized plate is not to be looked to, but the positive plate. The usefulness of the bimetallic storage batteries, in which the lighter metals zinc and copper can be used, is then seen. In the Planté forms there must be a positive plate of a fixed size, in order to get the best results, but in the bimetallic forms even a small stick of zinc can be used, as it is alternately dissolved and deposited. Mr. G. H. Percival, in 1869, described such a battery, and the action was supposed to be as follows: Electrodes of zinc and lead being in sulphate of zinc, a current of electricity is sent through the battery, entering by the lead plate. The sulphate of zinc by electrolysis splits into zinc and the radical SO_4. The zinc is deposited upon the zinc plate, but SO_4 splits into anhydrous sulphuric acid (SO_3) and oxygen (O). The oxygen attacks the lead plate, and the oxide of lead being insoluble, the higher form or peroxide of lead is formed, (SO_3) joining with one molecule of water to form sulphuric acid, or $SO_3 + H_2O = H_2SO_4$. This liberation of free acid was the objection to this form of battery, as it rapidly reacted upon the deposited zinc, even when well amalgamated, hydrogen gas being given off, and there being in consequence a great loss of energy.

Sutton saw this objection, and used copper and lead in sulphate of copper. In this case, the deposited copper was not attacked by the liberated sulphuric acid, but the action continued until all the copper was taken up from the solution, which was shown by its loss of color. The writer does not know why this battery has not met with greater success, except perhaps on account of its comparatively low electromotive force and its varying battery resistance, there being good-conducting free acid at beginning of discharge, rapidly changing to the much more resisting sulphate of copper. This varying battery resistance is found also in Percival's battery, as also in all single-liquid salt batteries. D'Arsonval, in 1879, used carbon plates covered with the peroxides of lead and manganese, and zinc in sulphate of zinc. This battery was open to the objection of free acid, which would condemn it, without taking into consideration the formation of sulphate of lead and disintegration of the carbon plate. Case, of Albany, has attempted to overcome the liberation of free acid, by placing in the solution of sulphate of zinc enough magnesia to neutralize it as it is formed. There is no doubt but that by this means the zinc will be deposited in a firm and compact form, and that local action will be decreased while the battery is at rest. As he starts with sulphate of zinc upon charging, and ends with sulphate of magnesia, data are needed as to electromotive force of charging and discharging.

The writer has designed a battery which attempts to prevent this production of free acid. The principal novelty is a porous cup or partition. The battery consists of an electrode of zinc in sulphate of zinc of about 30° Baume, and a porous cup containing an electrode of lead formed by the Parker-Elwell process, in dilute sulphuric acid. The action of the battery is as follows: the current enters by the lead electrode, the zinc sulphate is decomposed, zinc is liberated and deposited upon the zinc electrode, the radical SO_4 is liberated at the head electrode, but splits into SO_3 and O, the oxygen oxidizing the lead plate to PbO_2, and SO_3 joining with one molecule of water to form sulphuric acid, or $SO_3 + H_2O = H_2SO_4$. This acid is retained by the porous cup. The zinc is kept well amalgamated by a small quantity of bisulphate of mercury, and is but slightly acted upon by the acid, which in time slowly leaks from the porous cup. Upon discharge, the sulphuric acid leaves the cup, attacks the zinc, forming sulphate of zinc, while the lead plate is reduced from the peroxide, to lead oxide or spongy lead, as may be desired. It will be seen that this battery scarcely differs from that of De la Rive, except in the substitution of lead for platinum, the resistance thereby being reduced by largely increased surface, and the expense being much less. We get a higher electromotive force than the Planté cell, but increased resistance on account of the porous cup. The weight is much less, on account of the use of zinc, instead of lead, for the positive plate. The writer has had five cells in successful operation at the Naval Observatory. The useful zinc surface of each is 200 square inches, and lead surface 1,000 square inches. The average resistance per cell is 0·25 ohm, and the current is remarkably steady, working between the limits of 2·3 and 2·0 volts. As far as can be ascertained with instruments at hand, and with lead plates not well formed, something over sixty per cent. is returned. The lights used are from three to six candle power, and are

for the purpose of illuminating the fields and levels of telescopes. The charging, for economy, is done by a small hand Farmer machine, converted so as to be worked by an Otto gas engine.

W. S. HOGG.

EDUCATION OF THE AMERICAN CITIZEN.*

By Dr. R. H. THURSTON, Director of Sibley College, Cornell University.

Mr. President and Gentlemen:

Could the quiet dweller in the little hamlet which besprinkled this beautiful spot with its scattered cottages and green pastures a generation ago only, now return and look over the same lovely valley and along the same beautiful stream so familiar to him then, he could hardly fail to be strangely impressed by the wonderful change which had been wrought in the short space of three or four decades. Could he look abroad over the whole country, and could he trace the changes which the hand of man has effected north and south, and east and west, from the great lakes to the Gulf, and from the Atlantic to the Golden Gate at the green Pacific slope, he would probably find no spot in which the wonderful progress of a nation toward a realization of the dreams of its founders, of the men who, but a century ago had framed its foundation laws, had established its policy and principles, and had shaped its now accepted traditional methods of working and striving toward the higher and the better, the greater and the nobler; no spot in which their hopes and aspirations are more perfectly illustrated in the process of fulfillment than in a great city springing up here among the wilds of mountain and forests, attracting workers and "captains of industry" from all directions, raising wealth from the depths of the earth, building mills, manufactories, and dwellings all over the green acres of those earlier days, and giving profitable and honest labor, comfortable homes, and all the privileges and benefits of civilization to thousands of earnest, intelligent, industrious, and thrifty men.

Here he perceives the lines of steel rails, as he stands perchance upon the lofty steeps above the town, leading out on every side, their double threads of metal off into the invisible distance and away into the great world, out of sight and beyond, into which are sent the ten millions of tons of coal, black and dirty, but wealth giving, comfort producing, and productive of all material good, which a host of honest hands are raising from the bosom of Mother Earth, from the great reservoirs that were filled by a bountiful nature for the benefit of man millions and millions of years before his advent upon the earth. Over these slender lines of steel are brought the thousands of tons of merchandise, the food and the clothing, the comforts and the luxuries, which the great world outside, from Arctic to Antarctic, and from the Atlantic around to the Atlantic again, give in return for that black wealth. The products of every clime, the spices of the Indies, the silks of Europe, the fruits of the Gulf of Mexico and the islands of the Caribbean Sea, the teas of China and the coffees of Brazil and of the Oriental archipelago, the wheat of Dakota, the rice of Georgia, the cattle of Texas and of the Western prairies, all contribute their share in return for the gifts of this favored spot to them.

There, along the banks of the stream which winds in picturesque beauty through the valley, are great rolling mills, the roar of whose machinery almost drowns the sound of the bell and of the shrieking whistle as the puffing locomotive rushes on its errand of peace to or from the outside world. Machine shops, mills, factories of every kind, industries of every kind, furnish empioyment to tens of thousands of these busy human ants, streaming, at the sound of the bell or the whistle, to and from these newly erected hives. The city itself astonishes the returned, errant soul. Long streets, bordered on either side by comfortable homes, avenues lined with the houses of the prosperous and with the more imposing houses of the wealthy, now are seen where, so short a time before, were only meadows and forests, marshes and rocky pastures.

The visitor is amazed and unspeakably impressed by the magnitude of the changes thus wrought by the ever busy hand of man. But, if he be a thoughtful soul, if he looks above and below, behind and beyond all this, what may we suppose his reflections to be? Will he not, while wondering with an amazement indescribable, yet ask himself, What is the end and aim of all this? To what does it lead? What can be the intention of the All-guiding Hand which has directed and permitted so much? Who are the men who are most benefited by all this strange upspringing of wealth and bounty from Nature's most favored home? What is all this to do for the world, what for mankind, what for the thousands who constitute the great mass of humanity, and among whom those most favored and most powerful are but as the rain-drop in the ocean? How are the masses of God's people to be made the gainers? What can and what will those who are most fortunate do for those who have a smaller share in all this outpouring of the best the world can give? How is all this to aid in the promotion of the end desired by every thoughtful man and of every good citizen? How are the people to be best assisted in their endeavor to secure for themselves and for their children healthful lives, truest happiness, and perfect liberty of soul and body, in the pursuit of all that makes life worth living? What are the duties, and what the responsibilities, of the wealthy? What the right methods of work on the part of those who direct all this army of delving and toiling mortals? How can all this be made most productive of the greatest good to the greatest number?

Prosperity brings to the prosperous not simply wealth, comforts, luxuries, but great duties, tremendous responsibilities; and every good citizen, and every honest heart, seeks to know what are those duties and what those responsibilities, so that he may, when he lays down this life and looks back upon the years of struggle, success, and final reward, feel that he has done what he has been sent into this world to do, and in such manner that, the end being come, he may say to himself and to his Judge: "I have done my best and have accomplished my task. I have done so much good that the thought thereof shall cheer me at the end." Such a life, so ending, is all that man can aspire to for this world.

Every good man, every earnest soul, having attained independence and some degree of security against the vicissitudes of this always vicissitous life, desires next to do something to help his fellows who have been less fortunate, and who are still struggling amid the waves of adversity, and striving to gain the solid rock upon which he has been so fortunate as to gain a resting place. He naturally seeks means of helping, and he never need be at a loss for opportunities; for the poor are always with him. But we are not here to-night to seek ways and means of promoting the welfare or of relieving the suffering of individuals. That task lies upon us, but its consideration is to be reserved for other occasions, and is the mission of another form of philanthropy than that which is now in our thought. It is a great task, and yet none too well performed; but we are to consider a still greater duty, and one of still greater range and more far-reaching effect. How may we best aid in those mighty social movements and those tremendous political changes which mark the mighty progress of the race toward a better and a more prosperous future?

What, we may ask, constitutes prosperity, when we consider the condition of a race or of a nation? Will it not be at once answered: That state in which the many are permitted to lead comfortable lives, availing themselves of the best of what are regarded as the necessaries of life, abundant food, good clothing, healthful homes, ability to suitably educate their children, the power of giving to the soul and to the intellect the nourishment that they crave? We need not ask what of the rich. They are too small in number to make it matter of importance, in such a nation, whether they are a few thousand more or less in numbers, or whether they possess and control a few millions more or less. Whatever their numbers and whatever their wealth, they can only properly find use for their wealth in giving to the able-bodied men about them steady and remunerative employment, and to the weak and incapable that charity which no true man ever refuses.

In every community, the maximum of comfort and the maximum of wealth are gained by the exhibition, in all right ways, in productive directions, of intelligence, integrity, and skill, of industry and thrift. That city, that State, that nation, which possesses these qualities in highest development is certain, in the end, to attain highest prosperity, provided the natural advantages of location are such as to give suitable opportunity for the application of these qualities in the productive arts of life. It is at once evident, therefore, that it is the duty of every citizen, and of every State, acting through its legislature and executive officers, to seek to promote these characteristics among the people; to seek to give employment to the industrious; to cultivate habits of skill and of application; to stimulate intelligence; to give all citizens the most useful knowledge; to promote thrift and forethought in every possible manner. Civilization reaches up to higher planes as it becomes capable of seeing farther into the future, providing for emergencies, and, combining the industry of the ant and the foresight of the bee, making itself secure in the face of every threatening, though ever so distant, cloud.

I have said that we have before us the duty to secure for deserving industry a fair field in which to labor. The questions at once arise: How is labor to be found fair field? How are the great armies of struggling workers to be provided with opportunity and relieved from the competition with other striving masses, in such a manner as may give them freedom from care and suffering and the assurance of all necessaries and healthful luxuries? The answer is obvious: By the diversification of industries; by the cheapening of the unsubstantial and of the perishable necessaries of life, and by the promotion of those changes always visible in every period of improvement, and evidenced by the introduction of new arts and of new products, available for the use of the people or demanded by the wealthy. As the progress of invention brings into use new machinery and increases the productiveness of the old, and thus displaces man after man from his hold upon life, new fields must be found for the laborer and new tasks must be provided for him.

We have the duty before us of cultivating the skill of the worker, and the promotion of the so-called skilled industries, and mainly with the end in view to which I have just alluded. In the competition with other nations and with other communities, it is vitally important that we should be able to do good work, and to secure a market that shall be steady and reliable, by the application of that skill in lines of production that are most safe against fluctuation or failure. It is important, also, that the highest skill should be attained by our people, in order that they may be facile, not only in the performance of stated operations in the existing industries, but also that they may be capable readily of turning their hands to new tasks, at any moment, should the work in which they are at the time engaged fail to furnish employment, or should it give less satisfactory remuneration than another kind of industry. With ability to produce a great variety of needed products, and with facility of transfer from one field of work to another, a nation or a community becomes independent, to the greatest possible extent, of the fluctuations constantly occurring in the great industries of the world. As may be seen the moment the subject is considered, the promotion of this facility of application of the mind to any or all arts is to be secured by instruction—by instruction of the child in the "kindergarten," of the youth in the "manual training school," and of the young man in the "trade school," of which more presently.

We are to stimulate and to cultivate intelligence in the people, in every citizen offering the best prizes, and the great opportunities to those who are best prepared to take advantage of them and of the chances coming to them. Education, the best and most fruitful education, must be given our people, wisely, carefully, persistently, if we would escape the terrible dangers to our nation and to our government which we so often see looming up in the near future, and presage by a thousand threatening clouds of misrule and lawlessness. The most selfish policy unites with the most noble form of philanthropy to urge us to look bravely and determinedly upon every sign of the possibly gathering storm and to adopt, promptly and courageously, every precaution against it.

It is a common saying among the wisest and most thoughtful of our wise and thoughtful fellow citizens that the great safeguard against all such dangers as seem now to threaten our country is the education of the people; but we may most seriously ask, *What is a real education of a people?* Is it the teaching of the three foundation studies to all our children? Is it the conferring upon our boys college diplomas? Is it the instruction of our daughters in Latin, in music, or in painting? What is a true education? Is it not the teaching and especially the training of the young with a definite understanding of the purposes for which life is to be lived, and in such a way that they may best accomplish those purposes? Is it not such a method of instruction as shall render them wiser and of better judgment, more skillful and readier in self-adaptation to all the demands that may be made upon them, in the work of a lifetime, in the pursuit, first, of the necessaries, next, of the comforts and blessings, and, finally, of the highest gifts and purest pleasures that life can give, each in order of necessity? It is certainly not the highest education of the few that mainly concerns us, important as that phase of education undoubtedly is, not only to the few, but to the many; but it is the education of the many *well*, that is to say, their education most perfectly, with a view to the use to be made of education by them. The people must be carefully educated with a view to the people's work in life, not so educating them that they cannot strive and struggle with fate, and conquer her, and fight their way onward and upward to the extreme reach of their powers, we may hope; but, at least, so that they may find themselves well prepared for the work which will certainly be theirs to do at the first, and for the great majority of them the work to which they must buckle themselves through life.

It is intelligence, not brute force, that governs the universe and conquers fate. Reuleaux tells us that one machine-using man, the average man of the inventive nations, does the work of twenty-four uncivilized but by no means unintelligent men. It is the humming spindles, the puffing engines, the rumbling iron-devouring mills, each directed by active brains, and guided by a few skillful hands, that do the work of the world; animal power, whether human or brute, accomplishes but a very insignificant part of the work of this busy world of ours. The 3,000,000,000 bushels of grain annually grown in this country is transported to the millions fed by it, over our 125,000 miles of railway, and over the 3,000 miles of ocean, not by man, but by the inanimate forces commanded by his intelligence; not by human or even by brute muscle, but by Nature's power, directed by the mind of insignificant man, defying Nature's wildest untrained forces. One-half of all the tremendous tonnage traveling the laywork of iron overspreading our land is food for workers on both sides of the ocean. The 5,000,000 tons of iron, poured in red, fiery, molten streams from the bases of our hundreds of blast furnaces in Pennsylvania, in Ohio, in New York, or in Virginia and Alabama, are carried to the mills, worked into sheets, into bars, and into wire, or into rails, by these same trained and harnessed natural powers; and all the machinery of all our mills and factories is cut, and carved, and wrought into shape by the same untiring forces. The 7,000,000 bales of cotton grown in the now free fields of the South are brought to New England mills and spun into threads, woven into cloth, and made up into garments by enslaved natural powers.

It is in view of such a life as this now familiar to us, in a world in which man is continually learning to bring to his aid more and more all the materials and all the powers that nature has to offer him, that we are to seek to make our education of our sons and our daughters, and of the whole people, a real and a good education, a *true* education, for the life opening before them.

The necessity of moulding the educational methods for our people to a form seen to be right, as viewed from this standpoint, was recognized many years before it become so modified. The Marquis of Worcester, in England, two hundred years ago, and the great French philosopher Descartes, the mechanician Vaucanson, and, later, many other wise men, saw this need; but it is only within a generation that the system now recognized as that demanded, though introduced a century ago, has made itself felt in the adaptation of the people to the requirements of the times. This system is, as a whole, denominated "technical education." The term is a good and a suggestive one, although it may not give us an adequate idea of the extent or the form of the whole system of which it is the representative. It will, upon careful consideration, be seen that a complete system of education of the people, with a view to preparing them especially for the work to be done by them, must include a very comprehensive plan of instruction of all our youth, and all our children, in order that no time or energy, no thought or strength, may be wasted in what will inevitably be a sufficiently long and arduous course of work and study. Any comprehensive and satisfactory plan for the education of the youth of our country must be such as will take the child at an early age, and gradually and efficiently, without injury to his mind or bodily health, give him the needed facility in the use of the hands and the required knowledge to make it easy for him to take up and successfully pursue his life's work. As I have elsewhere stated, such a plan to be satisfactorily complete must comprehend:

1. A common school system of general education, which shall give all young children tuition in the three studies which are the foundation of all education, and which shall be administered under compulsory law, as now generally adopted by the best educated nations and States on both sides the Atlantic.

2. A system of special adaptation of this primary instruction to the needs of children who are to become skilled artisans, or who are to become unskilled laborers in departments which offer opportunities for their advancement, when their intelligence and skill prove their fitness for such promotion, to the position of skilled artisans. Such a system would lead to the adoption of reading, writing, and spelling books, in which the terms peculiar to the trades, the methods of operation, and the technics of the industrial arts should be given prominence, to the exclusion, if necessary, of words, phrases, and reading matter of less essential importance to them.

3. A system of trade schools, in which general and special instruction should be given to pupils preparing to enter the several leading industries, and in which

* A lecture delivered at Rowing Association Hall, Scranton, Pa., Nov. 24, 1885, under the auspices of the Board of Trade.

the principles underlying each industry, as well as the actual and essential manipulations, should be illustrated and taught by practical exercises until the pupil is given a good knowledge of them and more skill in conducting them. This series should include schools of carpentry, stone-cutting, blacksmithing, etc., etc., weaving schools, schools of bleaching and dyeing, schools of agriculture, etc., etc.

4. At least one polytechnic school, in which the sciences should be taught and their applications in the arts indicated and illustrated by laboratory work. In this school, the aim should be to give a certain number of students a thoroughly scientific education and training, preparing them to make use of all new discoveries and inventions in science and art, and thus to keep themselves in the front rank.

6. A system of direct encouragement of existing established industries by every legal and proper means, as by the encouragement of improvement in our system of transportation, the relief of important undeveloped industries from State and municipal taxes, and even, in exceptional cases, by subsidy. It is evident that such methods of encouragement must be adopted very circumspectly, and with exceedingly great caution, lest serious abuses arise.

Such a complete scheme has, as yet, never been fully carried out; and yet it is easy to see that we are gradually working out its elements, here and there, piecemeal, and that the future, the near future, we may hope, will certainly see the whole system in full operation.

At Bloomfield, New Jersey, the authorities are introducing most successfully a course of instruction of both boys and girls in the use of tools into their public school system. A manual training school affords a means of rewarding merit at Girard College, where the best students and most promising youth are admitted into the woodworking and machine shops under instruction; and there, under the careful and skillful tuition of expert mechanics, I have seen boys of twelve doing work at the vise with hammer and chisel and file that many an old workman might be glad to rival. The city of Chicago has a manual training school; at St. Louis, Washington University is doing excellent work in well-appointed shops. Boston, in her great Institute of Technology, besides the classes of aspirant mechanical engineers, has organized other classes of boys ambitious to learn the use of tools, and is cultivating the special Yankee talent in a systematic and fruitful manner; and all over the country these primary technical schools are springing up.

A year or more ago, I received a letter from a capable and successful superintendent of schools in a Western city, saying that he had seen plainly the approach of the new era in primary education of the people for the work and life of the people, and desired to be ready for its advent in his own city, and asking to be instructed, that he might intelligently direct the changes of method and system inevitably to come in his own organization. He came East, and worked in the shop and studied under instructors all summer to obtain the requisite knowledge and skill. Fortunately, he proved a natural mechanic and an extraordinarily capable man, and he is now ready to lead in the movement when the looked-for time shall arrive.

Trade schools now form a part of every school of engineering, and schools of engineering are springing up all over the land. Massachusetts has two noble schools, the one at Boston—the Institute of Technology—the other the Worcester Free Institute of Industrial Science, both doing a magnificent work. Minor schools are being organized all over New England.

New York has her greatest school at the university where the great heart and prescient head of the now immortal Cornell has raised a monument that shall never perish. Schools of engineering and of architecture there give opportunities to young men to acquire scientific and practical knowledge of the several arts such as have never before been seen. The philanthropy of Cornell, seconded by the grand benefactions of Sage and of McGraw, of White, of Mrs. Jennie McGraw Fiske, and of Hiram Sibley, have built up the institution in which it is the expectation that the hope of its originator may be more nearly realized than any other place in the world. Said Cornell: "I would found an institution to which any one may go and obtain instruction in any study. It is there that the splendid gift of the friend of the founder, Hiram Sibley, himself once a penniless mechanic and a wage-earner, and still a friend of every mechanic and every penniless brother, has provided means for the establishment of a great system of school of engineering and of trade schools, in which the young mechanics of the coming generations may find opportunity of fitting themselves, by the study of the applied sciences of every industry and by systematic practice in the mechanic arts, to do the great work of the years to come. The training of civil, of electrical, and of mechanical engineers, the support of schools of carpentering and blacksmithing, of moulding and founding and of ironworking, side by side with the schools of pure science, of classics, and of all literature, philosophy, all honored alike, and all give equal standing, constitutes that distinguishing characteristic by which this youngest and wealthiest of technical universities is known throughout the world. Sibley College, with its museums and lecture-rooms, its workshops and laboratories, and the great university of which it forms so notable a department, link together the names of two great mechanics in imperishable renown.

Every State college in the near East or the far West is now endeavoring to do something to promote this greatest of social revolutions, and to aid in giving the nation a real education of the people for the life and work of the people. The munificent land-grant of the General Government, on which Cornell and these other colleges are founded, in part, and often wholly, was made mainly through the foresight and patriotism of Senator Morrill, and the name of that statesman should be honored forever as that of the parent of the modern, the true, education in the United States.

Who among us are likely to command of our children and our children's children honors such as these noble men now receive? And what nobler monument could man aspire to than these men have built for themselves—not in bricks and mortar, in material construction, or even in the great institutions to which their names are given, but in the hearts of the generations of men yet to people this land during coming centuries?

One cardinal principle may be stated as necessarily to be kept in view, in all our legislation and in all our movements, public or private, concerted or individual, directed toward the improvement of our condition as a nation. We can only promote the welfare of any class, rich or poor, of high or of low degree, by caring for the great body of the people. Nearly all great social and resulting political changes, whether slow and healthful in operation, or revolutionary and disastrous for the time, are seen by the philosophical historian to tend toward the elevation of the people. The many, not the few, are helped onward and upward by such changes. The citizen who desires to promote the interests of himself and his own, however selfishly, must, to succeed permanently and safely, make his interests identical with those of the people, and must seek to promote his own prosperity by advancing theirs. It follows that there is one feature of our work which is of prime importance, and this feature is one which is most studied by every intelligent capitalist, by every thoughtful employer, by every wise citizen. This is the method of securing correct relations between the workingman and the employer of labor. And it is to the individual rather than to the State that we are to look for a solution of the difficulties arising in this direction.

The principles involved in this matter are simple, the rights of both parties are obvious and distinct; and with fairness of intention and a real desire on both sides to correct and solve the problems presenting themselves, there should be no difficulty in making steady progress toward a just solution. As I have had occasion to assert on various occasions, and as I am sure all are willing to admit, the right of every man to buy or sell labor wherever and whenever he may choose, and wherever and whenever he can make the best bargain, is one of those rights which are natural and inalienable. The right of every man to engage in any vocation or to enter into any department of honest industry, to train his children for any productive occupation, or to secure for them any kind of employment, is an equally natural and inalienable right. The privilege of accumulating property to any extent, and by any honorable and legitimate means, is also naturally and legally accorded to every citizen. It would seem obvious that one of the first claims of the citizen upon the State is that he shall be absolutely assured of these as constitutional rights. Any infraction of such rights, and any attempted contravention of such privileges, whether by individuals, by legally constituted corporations, or by associations unknown to the law, should be promptly dealt with, and so severely, whether the culprit be of high or low degree, that the offense shall not be likely to be repeated.

No legislation should be permitted that shall injuriously affect any morally unobjectionable industrial enterprise or that shall impede any fair commercial operation, whether in the exchange of commodities or the transfer and use of capital. Only such a tariff system, even, can be safely permitted as shall encourage fairly the growth of such new industries as are adapted to our climate, soil, and other natural conditions.

The prosperity of a people is dependent upon their industry, integrity, skill, and enterprise, as well as upon the natural resources of the country; and the object of every government and of all legislation is to protect the people in their right to a fair reward for their industry, skill, and enterprise, to promote that mutual confidence that comes of real business trustworthiness, and to develop the natural resources and advantages of the State. The protection of the individual in his right to learn, to labor, and to traffic; the encouragement of natural enterprises, the diversification of industries, the promotion of the ability of the people to produce valuable materials of all kinds of products of the higher classes of skilled industry, the encouragement of invention and the making of the nation independent of all possible rivals or enemies in the production of whatever is necessary to the existence or the comfort of the people, are all perfectly proper objects of legislation. No legislation which neglects or opposes these objects can aid us. No legislation can serve the nation which aims to help either the employer or the employe, either the capitalist or the laborer, alone. No industry can permanently succeed which does not make both classes prosperous, and no statecraft is deserving the name which does not aim at the support of both. If either is discouraged and driven out of the field, business ceases, and suffering results.

Again, force and intimidation have no place in matters of business. All legitimate operations, whether in commerce or manufactures, are the result of mutual agreement for mutual advantage. Strikes and lockouts, as well as their usual but shameful concomitants, intimidation and violence, are wholly out of place in a perfect industrial system, and should be discouraged as absolutely opposed to the spirit of civilization and to the letter of our Declaration of Independence. The simplest principles of political economy and social ethics cover this matter fully. Labor, like any other salable possession, will have a value determined accurately by the great law of supply and demand, and the interruption of traffic in labor, and at the same time the compulsory interruption of production, in the end only result in the serious injury to both parties to the controversy and to the whole country as well.

The introduction of a general system of arbitrament, the formation of unions between associated employers, the diversion of the trades unions into their legitimate channels of usefulness, will ultimately, we may be sure, effectually reform all the existing abuses in this direction. Already workingmen are learning that strikes almost invariably cost far more than they gain; capitalists are beginning to understand that their pecuniary interest, as well as ordinary humanity, dictate careful consideration of and respect for the rights and interests of labor; and ere long, when employers sustain labor exchanges in all our great cities, and when trades unions confine themselves to benevolent enterprises and the assistance of those members who desire to reach better paying fields of labor, we may expect to see every industry settle down to a steady, unintermitted routine which will give maximum production, while every worker will have uninterrupted employment at rates of pay which will be the maximum value of the labor sold. If every boy were made familiar with Nordhoff, and every man with Adam Smith and Spencer and Mill, we might hope that it would become universally understood that highest prosperity can only come when business can proceed without interruption by strikes, lockouts, or unintelligent legislation.

The elements of social economy are yet to become known to our people, the most obvious principles of statesmanship are yet to be learned by our legislators, and we have still to look forward to a time when our men of business and our working people shall be fairly and respectfully considered by those who direct public policy. Before the needed reform can be made productive of general good, we must return to the original theory of our government, that all government has for its object simply the preservation of the rights of the people in their pursuit of the best life, the highest liberty, and the purest happiness; that it should guarantee to all, of whatever race, creed, powers, or sex, a common right to live, to learn, to labor, and to acquire and hold property, with absolute freedom of thought, speech, and right-doing.

To attain all that we desire, and to secure highest efficiency in our political and social system, we must have a business man and a working man's government. The professional politician and the machine system must become extinct. Our public policy and our law-making must be made subservient to industrial interests. The people, and not self-seeking politicians, must frame the code and direct the expenditure of public funds.

But the world is moving on. On every hand we see the progress of the new views and of the newer practice in the education and training of youth and in the promotion of the true welfare of the people by the operation of new social forces and methods. The organization of trades unions is beginning to be seen to be right in itself, and it is beginning to be perceived that the methods of employing the great power so organized have often been wrong. Ere long we may hope and expect that it will be recognized universally, as a very evident fact, that the true office of this system of confederation is not to promulgate socialistic doctrines, not to encourage and sustain strikes, or any other violent interruption of industrial operations, or any interference with the rights of others, but to secure respectful consideration from all employers, to secure settlement of difficulties by arbitrament, and especially to aid the working people by adjusting the supply to the demand in the labor market, withdrawing men from underpaid districts and sending them into those parts of the country and into those branches of business in which comparatively high prices paid for labor prove the market to be understocked; by caring for the weak and the old; by promoting the interests of the working people—which means the interests of the nation—by all proper means.

When every boy and girl in the land shall have been guaranteed the privilege of learning any business and of entering into any occupation that he or she may find most suitable and most satisfactory, we shall have gained much in the direction of emancipation from the only modern form of slavery tolerated in civilized countries; but this means not only freedom to enter any business, but opportunity to learn the facts, to secure the training, and to obtain the instruction needed to make the aspirant fit for his chosen work. The individual must be carefully taught, and his education must be directed with the aim to give, at the least possible cost in time and strength, as well as in money, a preparation for all the duties to come to the learned, whether in everyday work or in social life.

We must call in science to our aid, and must learn of her not only the means of accomplishing our work and of completing the daily task, but we must seek of her knowledge of the best means of making our earnings most permanently profitable to us. She must teach what foods are best and cheapest in view of their life-sustaining and power conferring properties, what materials are best for clothing, what for daily wants in all the thousand directions in which we may apply the products of our varied industries. As she has already taught us that the Scotch peasant with his oatmeal, the German workman with his black bread, the old Roman with his crushed, unbolted wheat, are all followers of her ways, so she must be called upon to teach us, in every branch of our daily life, to reach up to higher attainments in skill in all arts, in every useful and every pleasurable function of existence.

And, when the time shall come when the new methods of training shall have become well engrafted upon our social system, and when the new education shall have become so well understood and so well interwoven with our whole political economy that the rising generation shall find the world into which they enter ready to receive them, and to do right by them, to teach them not only what they are to do in the world, but with the most intelligent and beneficent foresight prepared to train each of them in body and brain, in soul and intellect, to be all that nature gives them capacity to be; when, by that process of advancement and growth which is illustrated in every department the generations have profited by such education, each advancing beyond the mark reached by that which preceded, what in the course of years may we not hope for and anticipate?

We shall see all nations at peace; for the progress of the science and art of war is becoming such that warfare must cease because of the deadliness of its implements and the cost of its operations. As the introduction of firearms, by making an intelligent mind in a weak body the equal of any other individual in however strong a frame, so the modern methods and appliances of war make the intelligent and peace-loving nations safe against aggressors, from whichever side they may come. We shall see a great people covering the land with comfortable homes, filled with happy and contented families, enjoying all the necessaries, all the comforts, and the healthful luxuries of life; the father, intelligent, industrious, safe against the now existing fluctuations and uncertainties of employment, earning all that is needed for his family in a few well-spent hours, finding other hours of leisure to be still more satisfactorily spent in the cultivation of his own mind, in the training of his children, and in mutual entertainment with his family; the wife, relieved of the pressure, hurry, and worry of the wife of the workingman of to-day, finding healthful employment in her household duties, with ample opportunity to cultivate a few pleasure-giving accomplishments, to teach her boys and girls all those beautiful thoughts and soul-sustaining principles which only a wise and loving parent can effectively inculcate, with still time enough for affectionate intercourse with her husband

and for that quiet, solitary communion with herself that every womanly soul needs at times; the children studying at school, and in the fields, science and nature, the principles underlying every useful art, acquiring dexterity of hand, maturity of mind, subtle habits of thought, power of reception of knowledge, and facility in every mental operation, healthy, strong, happy, and lovable. The nation will comprise millions of such homes, with here and there a man of wealth ministering to those whose fate lies in his hands; dispensing to others what is given into his charge. Education will be free to all, and as valuable as free. Accumulated wealth will be distributed for the public weal, and the human soul, freed from the chains of adversity which now so sadly fetter it, will rise faster and faster, and attain heights as yet undreamed of.

We can already see some signs of this approaching social millennium; every good citizen is seeking means of alleviating distress, of helping his neighbor, of promoting the public weal. Wealthy, intelligent, and generous men are daily seeking opportunities of investing their fortunes in ways that shall help mankind; all our methods of education are improving; on all sides arise institutions which, while perpetuating great names like those of Stevens and Rose, Case and Johns Hopkins, and of Cornell and Sibley and Sage, are the greatest of all possible safeguards against retrogression and are an assurance of never-ceasing progress.

Science and art are, day by day, and year by year, coming more and more into accord. Science teaches us the great facts of natural phenomena and the great laws controlling them in all their manifestations; and art is profiting more and more by such knowledge as times moves on.

Speaking, on another occasion, before scientific men, of this "mission of science," I have expressed thoughts that have a fitting place here: Science has taught us to send printed messages across the oceans and across the continents, girdling the world with her mysterious wire; she has shown us how to drive the railway train, with its hundreds of tons of merchandise and living freight, faster than bird can fly; she has helped us give to the people news of every land, gathered in every clime, and brought to us by messengers swifter than the shadows of the sun, and printed on millions of sheets between the first glowing of the dawn and the rising of the orb of which Aurora is the messenger; she has given practical expression to a myriad of other hardly less magnificent philanthropies. Yet the mission of science has made but the veriest beginning. It still remains to her to perfect and to systematize a thousand new industries, to invent as yet unimagined new arts, to bring the laborer worthy of his hire all that he needs, and all that he can desire for his own comfort and for the care and comfort of his family; to so adjust the power of production to that of consumption, and both to the working capacity of the world, that the now seeming natural conflict between the employer and the employe, between labor and capital—that fallacy which is the support of every demagogue—shall no longer have even the appearance of existence. She has still to do her part toward the reduction of all systems of government to the one only correct form—that in which the people are governed by the people, for the best good of the people, and in which legislation is solely directed toward the protection of life, of liberty to do right, toward the support of the industries of the country, the sustaining of a system of education that shall give to every citizen the opportunity to fit himself with maximum efficiency for the duties of a well-planned life, and the encouragement in every right and reasonable way of all that tends to aid the material and the moral welfare of the community.

She has all this and much more to do; and her highest work will be found to include, I think, important modifications of the methods of evolution and of conformation of the race, thus accomplishing, under the guidance of our science, such tasks as lie before him to accomplish. The "coming man," with his greater frontal development, his increased mental and nerve power, his growing endurance and probably lengthening life, will be the greatest of the products of this scientific development, and the noblest of all these wonderful works. And may it not be possible, in the better days of that future into which we may now barely get the faintest glimpse, when the increase of the population of the world shall be limited, not as now by the maximum of misery and suffering bearable by the race, nor yet by art, nor by a Malthusian system, but by the rate of expenditure of vital power in the operations of the mind, of the intellect, and of the affections, when those who are brought into the world shall have fair prospect of being permitted to lead happy and prosperous lives, when suffering and misery shall have been reduced to a minimum—that we may see man taking the place assigned him by Ruskin. Says that great master of expression: "All the power of nature depends upon subjection to the human soul. Man is the sun of the world; more than the real sun. The fire of his wonderful heart is the only light and heat worth gauge or measure. Where he is are the tropics; where he is not, the ice-world." May not this development of the human soul be, after all, the true mission of science?

As a toil-worn traveler, wearily faring homeward at early dawn, skirts the western shore of some broad lake, picking his way by the uncertain but always increasing light penetrating the cloud-beflecked sky, at last sees in the east the uprising sun, and watches its steadily growing disk and the wide-extended sheaves and pencils of splendent golden light, silvering and gilding and magnificently tinting every snowy pile of vapor, etherealizing all the low-lying mist that hides the bosom of the lake, and sees finally, across the rippling waves stirred by the first gentle breezes of the dawn, the flashing of a broad band of glory, each wave at the distant shore catching up its share of the wonderful illumination, each its handful of the beautiful light, each passing it onward to the nearer swell, and each catching new beauty from the passing beams of the day-god, until the eyes are dazzled by the spreading sheen, and all the scene is surcharged with light, until the glory covers the weary one, lightening his heart, cheering his soul, quickening his step, and sending him homeward, with all his sadness gone, refreshed, hopeful, and happy—so man, plodding onward, sad, overburdened, and despairing, toiling wearily over the shifting sands of life, at last has seen, across the expanse of eternity, along the shore of which he wanders, the first bright beams of the light of science, heralded, but hidden, through a dawn that had lasted for centuries; and, as the bright luminary that is to guide him through all the future has arisen, steadily and constantly, among the obscuring but breaking clouds of the dark ages, the mists have been dispelled, the clouds themselves have received golden and silver linings, and the all-pervading beams, caught and reflected, but always advancing, have finally reached the hither shore, and man, enlightened and strengthened, with new insight into a brightening life, himself advances, with new courage and renewed hope, toward that future which it is the heaven-directed mission of science to illumine with the radiance of ever-increasing knowledge.

THE PARISIAN SOMERSAULT TURNERS.

SUCH is the name that has been given a new plaything which is shown in the cut. The toy, being placed upon a table, is held with the left hand while the right turns a winch that twists two pieces of rubber that form a spring. After the apparatus has been wound up the winch is released, when, under the action of the rubbers, two rods provided with small leaden balls begin to revolve and carry along two dolls.

The counterpoises on sliding along the rods, as they approach the vertical through their rotary motion, change the center of gravity (which comes abruptly beneath the center of suspension), and communicate a

THE PARISIAN SOMERSAULT TURNERS.

shock to the dolls that causes them to turn head over heels in jumping over each other. By the very fact of their leap the dolls produce the same effect upon the leaden balls as the latter had produced upon them, and so on until the motor runs down.—*Science et Nature.*

STRENGTH AND DEXTERITY.*

Jugglers.—The tricks performed by jugglers afford a most wonderful example of the perfection that our senses and organs are capable of attaining under the influence of exercise.

The juggler is obliged to give impetuses that vary infinitesimally. He must know the exact spot whither his ball will go, calculate the parabola that it will describe, and know the exact time that it will take to describe it. His eye must take in the position of three, four, or five balls that are sometimes several yards apart, and he must solve these different problems in optics, mechanics, and mathematics instantaneously,

FIG. 1.

ten, fifteen, twenty times per minute, and that too in the least convenient position—upon the back of a running horse, upon a tight-rope, upon a ball, or upon a barrel that he causes to revolve. His dexterity is wonderful. Many jugglers are content to perform their feats of skill with their hands, and, in addition, do balancing worthy of remark.

We can obtain experimentally some idea of the dexterity shown by a juggler by trying for ourselves the simplest of his tricks. Whoever is capable of throwing two balls into the air at once, and catching them in succession while standing steadily in the same spot, and without being obliged to step to the right or left, or undergoing contortions, is endowed with an undoubted aptitude for juggling. On another hand, whoever can stand upright upon a rickety chair without any feeling of fear, or cross a country brook, not upon a tight-rope or wire (which would be too much to ask for a *debut*), but upon a plank of two hands width, and do this without a quick palpitation of the heart, has an aptitude for tight-rope walking.

To perform with a couple of balls, however, is quite simple, and many children succeed in it after a few days' practice. They proceed as follows: Having a ball in each hand, they throw the one in the right vertically into the air, pass into the right the one that is in the left and throw this up too, receive the first ball in the left hand and pass it into the right, throw it up again, and so on; so that the two balls are almost constantly in the air, save during the time it takes to receive the ball with one hand and pass it into the other. If, instead of using both hands, the child employs but

FIG. 2.

one, receiving and throwing one ball while the other is in the air, the difficulty is greater, and the young man who can perform this operation twenty times without dropping one of the balls can treat the artists of the circus as a confrere. To perform with three balls, it is necessary to have been taught by a professor. Moreover, it should be remarked that the art of juggling has sufficient advantages, as regards the development of the touch, the quick calculation of distances, the nimbleness of the fingers, and the accuracy of the eye and of motion, to cause it to be added to those gymnastic exercises which children are taught at school. It is to this art that the celebrated prestidigitator Robert Houdin attributed the dexterity and accuracy that he displayed in his tricks. In his memoirs, he relates that, while taking some lessons from an old juggler, he applied himself so closely to the exercises that at the end of a month he could learn nothing further from his instructor. "I succeeded," says he, "in performing with four balls, but that did not satisfy my ambition. I wished, if it were possible, to surpass that faculty of reading by appreciation, which I had so much admired in pianists; so I placed a book in front of me, and, while the four balls were flying in

FIG. 3.

the air, accustomed myself to read without hesitation. It could not be believed how much delicacy and certainty of execution this exercise communicated to my fingers, and what quickness of perception it gave my eye. After in this way rendering my hands supple and obedient, I no longer hesitated to directly practice prestidigitation."

In order to keep their hand in, professional jugglers have to exercise daily, since a few days of voluntary or forced rest would necessitate double work in order to give the hands their former suppleness and dex

* Continued from page 8338, No. 522.

terity. As well known, the same is the case with the agility of danseuses, with whom one day of rest often means more than eight days of double work.

When a person knows how to perform with balls, the substitution of bottles, daggers, plates, or burning torches for these presents no difficulty. Such performances as these have recently been given by two young women at the Hippodrome, while standing upon superposed wires (Fig. 1).

Some jugglers perform with objects of the most diverse nature, throwing up, for example, at the same time, a large ball, an orange, and a piece of paper, and giving these articles of different size and weight such an impulsion that each falls and is thrown again at the moment desired. Some jugglers, as a support, use merely a simple wooden bar held vertically, and upon the top of which they perform their various feats of dexterity or contortion. It is the same apparatus formerly used by Greek acrobats, and, by reason of its form, called *στανρον* (perch for fowls). Some acrobats even balance themselves on the head at the top of this perch, with their legs extended in lieu of a balance-pole. Their arms are free, and they eat, drink, smoke, shoot off a pistol, perform with balls and daggers, and, in a word, perform the most diverse feats (Fig. 2).

Some jugglers are capable of performing extremely curious feats of dexterity with the most diverse objects; for example, with rings that they throw into the air, with hats that they revolve by striking the rim, or with a flag or napkin that they revolve. These hats and napkins no longer seem to obey the laws of gravity. Others, by means of a streamer, form helices and graceful curves, and others again, by means of a simple bit of paper, succeed in reproducing the Japanese butterfly trick.

Japanese maidens are noted for performing this with extraordinary grace and skill. In a house of the middle classes, after a meal, a young girl, in order to do honor to her parents' guest, will take a sheet of rice paper, and, by means of the nail of the little finger of her left hand, cut out a figure of a butterfly. Then, taking her fan, she will move it gently, when the butterfly will soon be seen to rise, apparently hesitate, leave the table, and flutter in the air. It will fly away, then return, and afterward ascend to a great height, and then flutter to the floor. It will settle down, now upon a vase of flowers, and now upon the head or shoulder of one of the persons present, and enter a casket and come out again. The maiden will shape another butterfly, and then one or two others, which will soon be gamboling with the first, and a curious spectacle will be offered of simple bits of variously colored paper fluttering, like large, tamed butterflies, around their charmer.—*La Nature.*

ON THE MICRO-ORGANISMS OF POTABLE WATERS: THEIR LIFE IN CARBONIC WATERS.

By Dr. T. LEONE.

THE analysis of potable waters, until the most recent times, has been in the exclusive competence of chemists. The existence of minute, microscopic, living organisms in potable waters has been known, but the want of suitable methods has always compelled analysts either not to occupy themselves with this question at all, or to do it in a perfunctory manner, including these beings in the determination of the organic matter.

But the existence in nature of pathogenic organisms, being recognized and confirmed, has already passed into the domain of science, and the probability that some of these may be found in waters enables us to foresee what a part of its territory chemistry must, in these researches, yield up to bacteriology, as soon as this new science shall have reached its full development.

And, in fact, it is beyond doubt that by the ingenious methods of culture of Robert Koch we have found a good method for such investigations, by which it is sought to complement the chemical analysis of water by its bacteriological examination.

Many experimentalists who have occupied themselves with the study of microbia on Koch's method have contented themselves with the summary appreciation of the value of a potable water according to the number of microbia present capable of producing "colonies" in gelatin. It is believed that the bacteria derived from putrescent animal matter produce colonies which liquefy gelatin. From the number of such colonies it is believed that we may form an opinion as to the greater or less corruption of a water.

But the greater part of such experimentalists think that in these researches we have not been guided by an exact conception of the nature of these microbia. Indeed, since the majority of such experimentalists have not taken account in such researches of the time which has elapsed from the moment in which the water was obtained to that when it was experimented upon, and since these experimentalists have ascribed to a water thousands and thousands of microbia per c. c.—a water which may have required two or three days' journey from its source to the point where it comes to be examined—it is to be supposed that these experimentalists have disregarded the possibility that the purest drinking water may be a good medium for the culture of microbia. What value is to be conceded to these researches will be seen from what will be explained below.

My researches have all been conducted by the gelatin method. The gelatin employed for each cultivation was 10 c. c.

The proportions of the substances used in preparing this gelatin were:

Water	100·0 parts.
Gelatin	10·0 "
Peptone	0·5 "
Extract of meat	0·5 "
Sodium phosphate	0·5 "
Sodium carbonate enough to produce a faint alkaline reaction.	

The cultivations were made upon plates of glass, on each of which the gelatin occupied a surface of 0·08 square meter. The water under examination was used in proportions of 0·1 to 0·5 c. c. If the quantity of microbia was so great as to interfere with their exact enumeration, it was diluted with distilled and sterilized water. The quantity used in each mixture was from 0·1 to 0·5 c. c. It was measured by means of a pipette of small caliber, graduated in tenths of a c. c. The preparation of such cultures was effected at temperatures below 30°. The gelatin, the pipette, the glass plates, the tubes—everything, in short, which came in contact with the cultures, or might have any connection with them—was duly sterilized, either by heat or by a solution of sublimate.

For the enumeration of the colonies, the culture, placed on a black ground, was covered with a plate of glass divided into square centimeters, and the colonies were enumerated with the aid of the microscope.

An appreciation of potable waters according to the criteria previously put forward, depending on the number of the colonies in general, or in particular on the number of those which liquefy gelatin, it was my first intention to examine if a potable water, although the purest, was such a nutrient medium for microbia as to render variable, and consequently erroneous, such an appreciation if the research is not immediately executed.

To this end, waters from different sources were examined, the results leading all to the same conclusion. I give those only yielded by the water supply recently introduced into the city of Munich from the Maugfall.

This water may be taken as a type of the purest potable waters. It contains not a trace of nitrates, nitrites, or ammoniacal salts; it leaves a residue of 284 mgrms., and the organic matter contained in a liter of the water may be oxidized by only 0·99 mgrm. of oxygen.

This water was brought to a cock connected with a main in which the water, coming directly from the great reservoir, was flowing continually. The cock was sterilized by the heat of a Bunsen lamp.

The recipient vessels were always washed with strong sulphuric acid, then with distilled water, and were then sterilized by being heated for an hour to 150°.

These recipients, filled to two-thirds and closed with plugs of cotton-wool, likewise sterilized, were left at rest in an atmosphere were the temperature ranged from 14° to 18°.

For brevity's sake I omit the details of the researches, and pass directly to an exposition of the results, confining myself to say that the figure given must be considered as the mean of the values furnished by such cultures.

The following are the results:

The Maugfall water arrives at Munich with five microbia per c. c.

After twenty-four hours, being left under the conditions above described, the number of microbia is found to have risen to more than a hundred per c. c. In two days the figure reaches 10,500. In three days, 67,000. In four days, 315,000. And on the fifth day there were more than half a million of microbia per c. c.

So rapid and considerable an increase of microbia in waters I find noticed only in a very recent publication by Dr. Cramer, Professor in the University of Zurich. Prof. Cramer, in his Memoir on the Waters of the City of Zurich, proves that the microbia in such waters increase rapidly on standing.

But it must be observed that the action of repose has no influence on the increase of the microbia.

The experiments which follow prove that the microbia in potable waters in movement multiply with the same rapidity, and in the same proportion, as if the said waters were at rest.

For these experiments were used glass tubes of the length of 60 centimeters and the diameter of four centimeters. They were washed with strong sulphuric acid, then with distilled water, and were then sterilized for an hour at 100° (in an atmosphere of steam).

These tubes were sealed at the lamp, after being half filled with the above-mentioned Maugfall water, and were then arranged perpendicularly to the axle of a wheel, so that the angle was intersected by the middle part of the tubes.

The wheel was set in continuous motion by a current of water, and the apparatus was so arranged that the entire water in the tubes was not at rest for an instant.

The experiment being thus arranged, I made, from time to time, examinations of the quantity of microbia contained in the water. I shall spare the description of the detailed results of these researches, which do not need to be repeated. Approximately, the same figures were found that were obtained above. The variation of the number of micro-organisms in the water in motion follows the same course as that of the same water when at rest. In both cases the number of the microbia reached on the fifth day the same maximum, and then decreased. On continuing the research, I found that on the tenth day the number of the microbia had fallen to 300,000, in a month to 120,000, and finally, in six months, the water contained only 95 microbia per c. c.

To appreciate, therefore, according to this method, the pollution, and in general the degree of corruption of a water, the examination ought to be begun immediately on taking the sample. In such an appreciation we ought also to take account of the increase of microbia during the flow of the waters, to the end that an extraordinary number of microbia may be attributed either to a natural increase or to an incidental pollution.

With respect to the five microbia per c. c. contained in the Maugfall water at the moment of its arrival in Munich (which from its source to its arrival at Munich takes about twenty-four hours), it has been observed that in this case the figure is not augmented during the course of the water. It has been observed, in fact, that the Maugfall water arrives at Munich under a pressure of five to six atmospheres. It is thence admitted, with much probability, that the vitality of the microbia is abated under this pressure. Dr. Karl Lehmann has experimentally demonstrated that such an influence is exerted upon many of the lower organisms by a strong pressure of oxygen. Prof. Maggi, of the University of Pavia, has found that the water of Lake Maggiore at depths exceeding sixty meters no longer contains bacteria.

As a rapid alteration of the hygienic conditions of a water results from the rapid increase of microbia, it seemed to me of not trifling interest to examine the behavior of carbonic waters which are ordinarily drunk in a period more or less long from their preparation.

For these researches there were prepared ordinary bottles of carbonic water (water saturated with carbonic acid under pressure), and at the same time there were taken as a check samples of the potable water which served for their preparation.

Care was taken to use sterilized bottles and stoppers. As for the apparatus for the carbonic water, the water-receiver was always kept filled during the preparation of our samples. Portions both of the carbonic water and of that unprepared were submitted to cultivation, to fix the initial conditions of the experiment.

From these cultivations it resulted that the carbonic water contained 186 microbia per c. c., and the original water only 115.

Upon each of the two waters were made comparative examinations at intervals of five days for a period of fifteen days.

In these researches it was found that while in the non-carbonic water the number of microbia rose in five, ten, and fifteen days from hundreds to thousands per c. c., in the carbonic water the number of microbia not only did not increase, but it diminished. In five days the number of organisms had fallen from 186 per c. c. to 87; in ten days, to 30; and in fifteen days, to 20.

This absence of increase in the carbonic waters may be due to one of the following causes: 1, action of carbonic acid; 2, action of pressure; 3, joint action of carbonic acid and pressure; 4, deficiency of oxygen. We may set pressure aside. I admit, indeed, that it may be sufficient to hinder the development of microbia, but in our case it is not necessary. In examining three qualities of carbonic mineral waters, *Giessel*, *Selters*, and *Apollinaris*, which were under very slight pressures, I have always found a scattered quantity of organisms which went on decreasing. But the decisive proof for excluding the necessity of pressure is in the researches made on carbonated water prepared at an ordinary pressure.

Into Maugfall water contained in sterilized bottles I caused to bubble for half an hour, with occasional stirring, a current of carbonic acid developed by the action of hydrochloric acid upon calcium carbonate.

The carbonic acid before passing into the water under examination was made to pass into two bottles containing solutions of sodium carbonate, to remove the traces of hydrochloric acid which may have been mechanically carried along by the current.

The carbonic water being thus prepared, the bottles were closed with ground glass stoppers secured with a layer of paraffin.

The water being left in this condition, it resulted from researches made in the period of fifteen days that in this case also the quantity of microbia did not increase, but diminished.

Pressure being thus excluded, there remained only as the cause hindering the increase of the microbia either the action of the carbonic acid or the want of oxygen.

But it has been possible, also, to exclude oxygen. Into the same Maugfall water contained in sterilized bottles there was passed for an hour a current of hydrogen, taking care to stir. The hydrogen, generated by the action of dilute sulphuric acid upon zinc, was washed by a passage through a solution of caustic potash. The bottles thus prepared were hermetically closed, and the water examined from day to day.

But the organisms in this water, which as regards oxygen would be in the same condition as the carbonic water prepared at the ordinary pressure, increased rapidly and similarly to the microbia in water which was in free contact with the atmosphere.

These results place it beyond doubt that atmospheric oxygen is not an element necessary for the increase of microbia in potable waters, and that the carbonic acid is the sole agent which interferes with the life of these organisms in carbonic waters.

These researches have been made in the Hygienic Institute of the University of Munich. The author feels it both a duty and a pleasure to return thanks publicly to the illustrious sanitarian Prof. Max Pettenkofer, who during his stay in Germany has given him the use of his laboratory and assisted him with suggestions.—*Gazzetta Chimica Italiana, vol. xv.*, 285; *Chem. News.*

THE ESSENTIAL CHEMICAL ELEMENTS OF PLANTS.*

By THOMAS JAMIESON.

THE question "What food do plants require?" is gradually receiving a shorter and simpler answer.

To meet the object of this paper, it is not necessary here to go back to the time when *natural soil* was deemed essential to plant growth, nor to the less remote period when those indefinite *organic* substances that are usually present in soil were supposed to be in some way or other necessary; nor need we go back even to the comparatively recent period when all the matters that are invariably found in plants, when analyzed, were regarded as indispensable. It is now well known that many experiments (prominent among which are those by Sachs, Stockmar, Wolff, Knop, and Nobbe) have shown that several of the substances that are usually found in plants are not really required; in other words, that certain ingredients are *essential*, while others are merely *accidental*.

We thus reach the present period, when the essential food of plants is believed to consist of, at most, eleven elementary substances, viz., carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, chlorine, and iron.

The special object of this paper is to approach the question whether the reduction in the number of essentials has reached its utmost limit, and to present experiments that go some way to show that a further reduction of the essentials seems demanded.

In regard to the first four of these elements, there appears to be no room for doubt, and they may therefore be passed over with a brief allusion.

Of these, the first three elements, viz., carbon, hydrogen, and oxygen, are so prominently important that, in any treatise on plants, they demand by far the largest share of attention, but as a rule they receive less notice than the minor elements, probably for the reason that nature undertakes almost the entire supply.

These three elements might be classed as a separate group by reason of two characters:

1. That it seems self-evident that they are essential to plants, from the fact that plants consist chiefly of compounds which are well known to be composed of definite or atomic proportions of carbon, hydrogen, and oxygen, viz., sugar, starch, oil, gum, etc.

2. That there is in nature an abundant and suitable

* Abstract of a paper read before Section B, British Association, Aberdeen meeting, *Chem. News.*

supply of these elements in the form of carbonic anhydride and water.

Nitrogen holds an intermediate position between the group just considered and the group to follow, inasmuch as it resembles carbon, hydrogen, and oxygen by forming part of one of the constant products of plants, viz., albumen, and existing in it always in such definite proportions as to preclude the possibility of the plant being developed without it; while, unlike these three elements, it is not provided in a suitable form by nature in sufficient quantity for full and rapid development of cultivated plants. Hence it forms one of the main ingredients that have to be supplied under the name of manure, and consequently it has always received the major part of attention. It is apart from the object of this paper to refer to those subjects which have given rise to so many experiments and discussions, viz., the natural sources of nitrogen that are directly at the command of the plant, and the merits of different artificial forms of nitrogen. It suffices for the present purpose to know that nitrogen is absolutely essential.

The third and last group of seven elements is the one to which attention is here specially directed. The elements comprising it are characterized by existing in plants in so inconstant and often insignificant proportions as not to convey a conviction, based on proportionate quantity, that they are essential.

Further, if they form any part of the organic compounds in plants, they do not, so far as is known, seem to enter into them in the definite chemical ratio that can be expressed in a chemical formula. Each element may thus be called upon to prove its right of admission, as it were, into the essential group.

Phosphorus is undoubtedly the most important member of this group. Many experiments, more or less specially directed to answer the question whether or not phosphorus is essential, have shown, more or less clearly, that it is essential; and within the last few years an opportunity was afforded me, in conducting the experiments for the Sussex Association for the Improvement of Agriculture, to add a few striking confirmations of this fact.

The analysis of the sand used as soil brought out that 99¼ per cent. is composed of matter insoluble in 50 per cent. boiling hydrochloric acid, and hence it may safely be assumed that this large proportion is totally beyond the command of the plant. When to this proportion is added the organic matter, the iron, and alumina, there is left about ¼ per cent., or 1 part in 1,000, of possible plant food, and this minute proportion is chiefly made up of lime and magnesia. The phosphoric anhydride, it is important to observe, is under 1 part in 10,000, equal to 1 part of phosphorus in about 23,000 of soil. The sand was thus practically destitute of plant food. While fortunately its mechanical consistency was such as to retain moisture well it was neither plastic and dense nor too open and loose, and hence formed a very suitable medium to perform the experiments on.

Uniformity in the composition of the plats was secured by carting it into large mounds, and mixing it repeatedly. A degree of precision is thus reached that permits of very small plats being used with accuracy, just as minute quantities are with accuracy acted on in a chemical analysis. The thousandth of an acre is a most convenient size under such circumstances. Without such precautions, but on a patch of ground as nearly equal in all respects as can be known, about one-hundredth of an acre must be acted upon. When the size of plat goes beyond this, the results must probably be regarded with the suspicion that the comparisons may not be reliable, owing to different conditions of soil and subsoil, and more especially to cultivation under different climatic conditions, which affect crops so considerably. For instance, part of a field sown with turnips during a slight shower has been found not to yield one-half of the crop grown on the neighboring soil of the same field, sown on the same day, but before the shower. As ten comparisons of 1-1000 acre cover only 1-100 acre, each cultivation treatment extends over so short a time that no climatic disturbant enters; while ten comparisons of ¼ acre are equal to 2½ acres, over which the cultivation is likely to extend for several days. It is rare in our variable climate to get three successive days identical in regard to weather, and consequently the possibility of identical treatment is reduced to a chance.

Twelve of the plats were then supplied with a uniform mixture containing all the ingredients understood to be essential to plants, except those three that are supplied abundantly by Nature, and except also phosphorus. Phosphorus, however, in various forms, was then applied to ten of these twelve plats, and withheld from the remaining two. In those two plats from which phosphorus had been withheld the plants absolutely refused to grow beyond the first few leaflets, and made only abortive attempts to form a bulb. All the other plats gave full crops. The results were as follows:

Turnips (Water extracted).

	Form of Phosphate.					
	Coprolite.	Bone Ash.	Superphosphate.	No phosphate.	Steamed Bone Flour.	S. B. Flr and Coprolite.
Principal..	71·29	87·49	95·68	4·12	86·67	79·56
Duplicate .	94·58	84·25	79·36	3·09	84·01	80·04
Average ..	82·93	85·87	87·52	3·60	85·34	79·80

The experiments were conducted with certain modifications for other four years in the same plats, and practically identical results were obtained yearly. (In all the experiments, the results were checked by a duplicate plat, as shown in the above figures; but in the subsequent tables, for clearness' sake, only the average is given.) Strong evidence is thus provided that phosphorus is absolutely essential.

Next in importance to phosphorus comes potassium. Similar experiments in reference to this element gave results similar to those found in the case of phosphorus, but the decrease in the crop when potassium was withheld was not nearly so great as when phosphorus was withheld. It was only in the case of peas that any decrease resulted; in the case of turnips, the first year there was little or no decrease. This was probably due partly to the traces of potash in the soil and partly to the probable fact that potassium is not so dominant an element in plants as phosphorus. The following are the results for the first year:

Peas.

Potassic carbonate	30	oz.
" sulphate	33	"
" chloride	1*	"
" phosphate	33	"
" nitrate	47	"
No potash	21	"
No manure	3	"

Turnips.

Potassic carbonate	56·50	oz.
" sulphate	40·69	"
" chloride	0	
" phosphate	40·53	"
" nitrate	72·94	"
No potash	38·59	"
No manure	0	"

In the following year (1882), the experiments were repeated in the same plats, and the differences were more marked, especially in the case of turnips; that is to say, good crops were got where potassium had been given, and very poor crops where it had been withheld. Not only were the final weights less where potash was withheld, but the plants seemed unhealthy, especially in the leaves, which were short, thick, twisted, and leathery-like. The following are the results:

Peas.

Potassic carbonate	37¾	oz.
" sulphate	41¼	"
" chloride	9¾*	"
" phosphate	34½	"
" nitrate	33⅝	"
No potash	19⅜	"

Turnips.

Potassic carbonate	48	oz.
" sulphate	52	"
" chloride	55	"
" phosphate	55	"
" nitrate	62	"
No potash	19	"

A very interesting, and, as it turned out, very instructive, modification was made in the third year in this set of experiments. The two plats of both the pea and turnip series from which potassium had been withheld were each divided, thus forming eight half plats. From four of these halves potassium was still withheld; to other two halves potassium was given; and to the remaining two halves soda was given. Conditions were thus established to secure positive results side by side with the repetition of negative results. The experiments were thus calculated to show whether, on the one hand, the addition of potassium would cause the crops of turnips and peas to leap up to the line of the full crops, and, on the other hand, whether sodium, which resembles potassium so closely, could take the place of potassium. The results were sharp and decisive. The crops leapt up remarkably on the potassium halves, and remained stationary both in the nothing halves and in the sodium halves. By these and the previous experiments it thus seemed proved, first, that potassium is absolutely essential, and, second, that whatever function is performed by potassium, it cannot be performed by sodium. The following are the results:

Peas.

Potassic carbonate	51	oz.
" sulphate	59	"
" chloride	65	"
" phosphate	47½	"
" nitrate	64¼	"
No potash	12½	"
Potas. carb. (previously no potash)	64	"
Sodic carb	12	"

Turnips (in Wet State).

Potassic carbonate	54	lb.
" sulphate	53	"
" chloride	60	"
" phosphate	63	"
" nitrate	53	"
No potash	10	"
Potas. carb. (previously no potash)	68	"
Sodic carb	6	"

The information derived from the preceding experiments is merely confirmatory; the facts brought out were previously more or less unanimously accepted, and we have here merely convincing proofs of a satisfactory kind, which were perhaps not altogether unnecessary.

We now, however, approach evidence suggestive of a reduction in the accepted number of essentials, by the rejection of one or more ingredients which are generally supposed to be necessary.

The peculiar opportunity presented by the pure and congenial soil at command invited the testing of several of the other ingredients that are deemed essential in the anticipation of similar, though probably less marked, results. The first results, however, turned out very different from the anticipation that had been formed. They are as follows:

Turnip Crop (in Wet State) manured with Purest Manure.

Phosphorus withheld	⅛	lb.
Sulphur withheld	31	"
Nitrogen withheld	¾	"
Everything withheld	½	"
Magnesia withheld	34	"
Potash withheld	51	"

A more complete set was simultaneously started, but using pure chemical salts as manure.

Turnip Crop (in Wet State) manured with Pure Chemical Salts.

Phosphorous withheld	1/10	lb.
Sulphur withheld	51	"
Nitrogen withheld	6	"
Everything withheld	1/10	"
Nothing withheld	42	"
Magnesia withheld	49	"
Potash withheld	11	"
Lime withheld	55	"

* A remarkable result is shown above in regard to potassic chloride; but not to break the continuity of the subject of the essential food of plants, detailed reference to this circumstance is deferred. The large result from potassic nitrate is due to the large proportion of nitrogen of necessity given in supplying potash in this form.

These two sets of experiments had not proceeded far when it became obvious that some of the elements that are deemed essential are not essential, or exercised no effect in the early stage of the growth, or that the plants were finding a sufficiency of these elements in the soil.

In other words, they seemed to indicate that sulphur, magnesium, and calcium are not essential, or at least seemed to raise some doubt on that point. For the withholding of sulphur, magnesium, and calcium did not lessen the crop in any degree; on the contrary, the crops grown without them slightly exceeded the crop from which nothing had been withheld, as if the giving of sulphur, magnesium, or calcium to that plat had done injury. That the "lime withheld" plat should turn out so well may, to some little extent, be explained by the fact that the experimental station is only three miles from the chalky downs, and that breezes might have conveyed traces of lime, which, added to the traces already in the soil, might have sufficed. It should also be added that on two occasions it was found necessary to water the plants, and that this water contained some sulphates of lime and magnesia. It seemed hardly likely, but it may be possible, that these circumstances might account for some proportion of the large crop got when lime and magnesia were withheld, but they could scarcely account for the heavy crop where sulphur was withheld.

In consequence of the waterings above referred to, a third series was, later on in the same year, established on new ground, and also manured with pure chemical salts. The season was too far advanced to admit of having good crops and large differences, but the differences, such as they were, went clearly in the same direction as those of the former trials, that is to say, tending to minimize the influence of lime, magnesia, and sulphur on plant growth, and seeming to throw some doubt on the accepted doctrine that they are essential. The suspicion seemed still stronger against sulphur when actual analyses of the turnips gave the following results:

	Sulphuric Anhydride Per cent.	Calcium. Per cent.	Magnesium. Per cent.
Plant from plat from which nothing was withheld contained	0·055	0·083	0·042
Plant from plat from which calcium was withheld contained	0·028	0·081	0·041
Plant from plat from which magnesium was withheld contained	0·089	0·088	0·042
Plant from plat from which sulphur was withheld contained	0·012* / none.†	0 088	0·083

It thus appears from these figures that the calcium and magnesium are present in nearly equal quantities, and have in some way got into the plants apart from the manure, while the sulphur fluctuates as accidental substances generally do, but, in particular, it was absolutely absent in one of the turnips grown in the "sulphur withheld" plat.

Here, then, we have two facts: first, that a large crop was produced in a soil containing no sulphur, or only traces of it, and to which no sulphur was given in the manure; and, second, that the fully developed turnips thus grown gave on analysis no sulphur whatever. As regards calcium and magnesium, they having been found in the turnips, the evidence against them is weakened.

Obviously, the longer that these plats were treated in as similar manner the better would they they be suited to answer the same question, inasmuch as the disturbing traces in the soil would be gradually eliminated. The experiments were therefore repeated in the same plats in the following year, but in a modified form, that is to say, those plats which refused to yield produce when certain elements were withheld (viz., nitrogen, phosphorus, and potassium "withheld" plats) had now that element supplied to them, in the expectation that the crop would leap up to the normal position. This actually took place. The other plats (viz., the sulphur, magnesium, and calcium "withheld" plats), which had given good crops, had their respective elements still withheld, so that the evidence of their non-essential character would be strengthened or weakened according as there was a full or a deficient crop. Substantially, the evidence of their non-essential character was strengthened; the crops were good in each case. The following as the results:

Turnip Crop (in Wet State).

Phosphorus given	44	lb.
Sulphur still withheld	39	"
Nitrogen given	23	"
Everything still withheld	25	"
Magnesia still withheld	35	"
Potash given	37	"

Turnip Crop (in Wet State).

Phosphorus given	44	lb.
Sulphur still withheld	36	"
Nitrogen given	27	"
Everything still withheld	2	"
Everything again given	31	"
Magnesia still withheld	31	"
Potash given	33	"
Lime still withheld	31	"

The general result seems to foreshadow the exclusion of sulphur, magnesium, and calcium from the list of plant essentials, and to call for other experiments by other experimenters under such varied conditions as will settle the point.

Numerous experiments were simultaneously carried out in larger plats of ordinary soil of different kinds, namely, chalky soil, clay soil, and clayey loam. The results need not here be stated particularly, as it might complicate, and also because, the soil being impure, the results cannot be regarded as so reliable; but the general character of these results got on ordinary soils go far to prove what seems to be so well demonstrated by the pure sand experiments.

The remaining two elements supposed to be essential—viz., chlorine and iron—exist in plants in so infinitesimal proportions that it is doubtful whether, indeed, their admission into the list of essentials is fully ac-

* First bulb. † Second bulb.

quiesced in. To eliminate such traces of ever-recurring substances would require a special kind of experiment, which I have not yet been able to carry out.

In a sentence, reference might be made to collateral evidence by considering the subject of function. Regarding the plant as the natural food of the animal, and it being certain that lime is essential to the animal to form bone, and it being at least possible that sulphur and magnesia are necessary to animals, it might be assumed that this affords ground for supposing that plants, being the natural food of animals, will contain all the elements that are essential to animals, and that hence what is essential to animals will be essential to plants, for at first glance it may seem that in no other way could it be insured that animals would be duly supplied with their requirements. But while plants form the natural food of animals, water is their natural drink. Now, water never is pure in nature, and it is significant that its usual impurities are just those that we have seen have failed in those experiments to prove their right of admission into the list of plant essentials, viz., sulphur, magnesium, and calcium.

In hundreds of waters analyzed by the experimenter it has been found almost without, if not quite without, exception that the largest proportion of the solid matter in solution is composed of sulphates of lime and magnesia, from which animals would naturally obtain those essentials that do not appear to be essential to plants. Any substance present in plants and not wanted must be regarded as in the way. But some of these may be practically harmless and others hurtful.

This seems the proper place, therefore, to allude to the peculiar results obtained by the use of potassic chloride. The plants were actually killed, the symptoms being such as directly pointed to the action of free chlorine. The leaves were markedly blanched throughout in an early stage of growth, and ultimately the plants died. The explanation seems to be that decomposition of the potassic chloride had taken place, probably within the plant, the plant seizing the potassium which was essential to it, and liberating chlorine, which exerted its bleaching and poisonous influence.

A curious circumstance, however, is that in repeating the potassic chloride experiments in expectation of getting the same result, that result was not obtained in nearly so decisive a manner; for after suffering slightly for a time the plants revived, and although in the case of peas only a light crop was yielded, there was in the case of turnips a heavy crop. The difference in result was probably due to a difference during the early stage of growth in the proportion of moisture in the soil, or of the rainfall, which would have the effect of lengthening the time of admission of potassic chloride into the plant until it was able to resist its evil influence; in other words, of so regulating the rate of admission as not to have so injurious an effect. A somewhat similar effect was shown in the case of potassic sulphate, but instead of a blanching the leaves were slightly reddened as if by free acid. By and by, however, they recovered, and an average crop was produced. In this case probably sulphuric acid had been liberated, causing the reddish tint which is always produced by acids, but the circumstance that chlorine and sulphur under certain circumstances exert such evil influences seems to strengthen the contention that they are not essential.

A large number of experiments performed years ago in Aberdeenshire seem to point plainly to the pernicious effect of sulphur. The following is a summary of a few of the results. The plats were commenced in 1878, were manured yearly, and turnips sown yearly. In 1880, disease set in, but it was confined in great measure just to those plats which had got manure containing sulphur.

	Number of diseased plants.
Original number of plants in plat.....	300
And the result by the application of manure containing sulphur.....	297 296 272
Ditto, ditto, ditto, containing less sulphur.....	218 197
Ditto, ditto, ditto, containing no sulphur,	89 85 74

In the following year the average number of diseased bulbs was as follows:

	In loamy soil.	In clay soil.	In sand soil.
After complete manure containing sulphur.....	285	264	121
After manure containing no sulphur.....	51	46	33

The disease is a fungoid one, caused by the fungus *Plasmodiophora brassica*, and it is supposed that the sulphur predisposes to disease by merely weakening the plants, just as great excess of moisture, drought, or other evil influence lessens the resisting power of the plant in contending with its natural enemy.

It remains only to say that, although unfortunately this sand station is not at our command for continuing the same experiments on the same ground, a neighboring site has been obtained, and the experiments are again being conducted on a similar plan with the same care.

BULBOUS CALANTHES.

IT not unfrequently happens that when the treatment found to answer best for any particular plant has been so far proved by growers collectively as to be looked on as beyond doubt, some one makes the discovery that the plant in question can be made to thrive with directly opposite treatment, and the treatment thus newly discovered generally turns out to be something which the consensus of practice has proved to be wrong, or indifferent in its results compared with the generally accepted course. Of this character evidently is the cold treatment of Calanthe bulbs, recently advocated. The varieties of C. vestita are natives of Burmah, and have been in the country nearly forty years. C. Veitchi is a hybrid. Their merits for winter flowering cause them to be largely grown by many who cultivate few orchids, and by almost all who have collections of them, and I should suppose that there is scarcely an old hand among orchid growers who has succeeded in growing them up to the mark who has not tried and noticed the difference between bulbs kept in a warm house after flowering and others kept cool, and who is not convinced of the advantages of warm treatment; the latter favors the growth of better and larger bulbs than are forthcoming after keeping the old bulbs after blooming cold. It is well to note that the ability of Calanthes to flower is regulated by the size of their bulbs. Where the treatment was such as the plants require, I never yet saw an instance of big bulbs failing to produce proportionately more flowers than smaller ones. From the all but unequaled usefulness of these Calanthes for the decoration of a warm stove or orchid house and the time their spikes of bright flowers last, either on the plants or when cut, they, from the first, were particular favorites with me; and during the many years I grew them I tried all I could to do them well, and was far successful that I have had bulbs of the red-eyed variety of C. vestita strong enough to enable them to produce spikes bearing one hundred and twenty flowers each.

Those who have a knowledge of the intensely and continuously hot climate of the country from which these Calanthes come will not feel surprise at their doing best kept warm, even during the time of comparative rest, for they may be said to be never wholly dormant; as soon as the flowering is over, the growth buds for the following year at once begin to swell, if the bulbs are in a temperature warm enough to help them to do this. When grown strong, they increase more than doubly as fast as if the bulbs are comparatively small. With the treatment I gave them I soon had a large stock, which enabled me to try them in different ways. After blooming, I have kept the bulbs in different temperatures—from that which was cold enough to cause them to decay up to that of the warmest stove—and in every case the warmest quarters gave the best results. If keeping the bulbs cold effected any saving in the attention required in the cultivation of the plants, or any one was enabled by the cold treatment to grow them who otherwise could not, something might be said in favor of it; but where there is enough heat to grow Calanthes well (and they like as much heat as any plant will bear, provided they are kept close to the glass), the bulbs are just as easily kept in the stove in which they are grown through the rest of the year.

I have tried Calanthes in different kinds of soil, and could not see much difference in the results, provided other essentials in their cultivation were present. Some I put in turfy loam, others in fibrous peat, and others in a mixture of peat and loam, with in each case about one-fourth rotted manure that had been exposed on a vine border or an asparagus bed, with a little sand and some pieces of charcoal or crocks, and there was little or no difference in the size of the bulbs or in the quantity of flowers they bore. I found them to get much stronger when hung up over the path, with their leaves all but touching the glass, than in any other position, always using a thin shade when the sun came with any force on them. They attain a larger size with two or at most three bulbs put in a 7 inch or 8 inch pot than if more together; 2 inches of drainage is enough; when strong they root profusely, filling the soil full of their fibers. They should be potted just as the young roots are seen ready to issue from the base of the young shoot which is to form the new bulb; if the potting is delayed later, the young, tender rootlets already protruding are almost sure to get injured, which so far interferes with the season's growth that, like most orchids, when the roots have their extremities injured, they have not the power to at once make good the injury, like other plants. Care must be taken not to make the soil too wet during the short time intervening between potting and the roots getting hold of the material; after this, as the leaves attain size, water must be given freely until the growth is completed, when much less must be applied, or the roots decay before their time, the consequence of which will be that the leaves also die off sooner than they otherwise would do, interfering much with the appearance of the plants when blooming.

From the rapidity with which Calanthes increase when well managed, a sufficient stock for ordinary requirements is soon available. When enough are at hand, any one disposed to grow big bulbs capable of producing an exceptional amount of bloom may do so by the following means: After being treated in the way described for a couple of years, with the plants kept close to the roof through the growing season, the stock will be stronger than such as are ordinarily met with.

When the blooming is over, the individual pieces will usually consist of two or three bulbs of the previous summer's growth attached to the old bulb which has produced them; remove the smallest, letting the largest one still remain attached to the old bulb, which will generally remain sound another season, giving more strength to the single bulb to which the ensuing summer's growth is to be confined than if it was removed. Kept warm, as I have already advised, the bulb of the preceding season will in the course of a month or so after the flowering is over push two or three buds from the base, and sometimes one or two from the eyes near the top; reduce these to one, the strongest at the bottom, removing the others as soon as they are big enough to be got at. The old back bulb will frequently push a bud or two the second season, which also rub off. Each piece, now consisting of two bulbs as described, should have a 7 inch pot, or two pieces may be put in a 9 inch pot. In potting, keep the old bulb well against the side of the pot, or the young one next forthcoming will not have room to swell as it may be expected to do. Most likely more buds will be formed at the base or top of last year's bulb soon after the strong one left begins to push into growth; rub these out directly they appear, so as to concentrate all the strength in the one retained, by which means it should reach double the size of that of the preceding season which has produced

FINELY-FLOWERED PLANT OF CALANTHE VESTITA.

it. Follow a similar course the next year, confining the growth to one bulb; each plant by following this course will attain a very large size, producing flowers in abundance. The strongest may now be expected to produce as much as three spikes from the base, with one or two on the shoulder of the bulb, and not unlikely one at the extreme top. I have let half a dozen, which were produced as above from a single bulb, go on to bloom, but the number thus allowed lost something in the size of the individual flowers, which were considerably larger where the spikes springing from the bottom of the bulbs were alone allowed to remain; moreover, when so many were allowed to go on, it took a great deal out of the bulbs, for, as will be easily understood, the roots from their natural disposition to perish early, even when all that is possible is done to prolong their existence, are not in a condition to contribute much to the development of the thick succulent stem and the flowers it carries, which collectively are in a great measure so much drawn from the strength stored in the bulb.

The leaves of this section of Calanthes, being so much thinner than those of most orchids, are easily injured by either insects or too much exposure to the sun. It is scarcely necessary to say that where an attempt is made to grow large bulbs, care must be taken that the foliage does not suffer in any way, or the bulbs will not attain their full size and strength. When the plants are hung up overhead in the way recommended, not only are they benefited by the abundance of light they get, and without which it is impossible for them to attain a maximum of strength, but it admits of the syringe being better brought to bear on the leaves, by which means they are kept free from the attacks of red spider, thrips, and aphides, all of which, if ever allowed to have a footing, quickly interfere with the season's growth. The yellow-eyed variety of C. vestita is not quite so strong a grower as the red one, neither is C. Turneri. The beautiful varieties of the hybrid C. Veitchi can be grown similarly strong in the way described, by which means the color of their flowers is considerably intensified.—*T. Baines, The Garden.*

LIFE IN OTHER WORLDS.

By RICHARD A. PROCTOR.

IN considering the case of Mars, I suggested the possibility that, owing to the relative shortness of that planet's life-sustaining era, the development of the higher forms of life may have been less complete than on our earth thus far (still less than the development of those forms on the earth in coming ages). We may well believe that during the long period of Jupiter's existence as a life-supporting planet, creatures far higher in the scale of being than any that have inhabited, or may hereafter inhabit, the earth will be brought into existence. As the rule of nature on earth has been to advance from simple to more complex forms, from lower types to higher, so (following the argument from analogy) we must suppose the law of nature to be elsewhere. And time being a necessary element in any process of natural development, it follows that where nature is allowed a longer time to operate, higher forms, nobler types, will be developed. If this be so, then in Jupiter, the prince of planets, higher forms of animated conscious being will doubtless be developed than in any other planet. We need not, indeed, point out that the supposition on which this conclusion rests is merely speculative, and that now, when the laws of natural development have so recently begun to be recognized, and are still so imperfectly known, the argument from analogy is (in this particular case) necessarily weak. Nevertheless, analogy points in the direction we have indicated, and it is well to look outward and onward in that direction, even though the objects within the field of view are too remote for us to perceive their real forms.

But, limiting our conclusions to those which may be justly inferred from known facts, let us inquire how the subject of life in other worlds presents itself when dealt with according to the relations above considered.

It is manifest at once that whether our new ideas respecting the present condition of Mars or Jupiter be correct or not, the general argument deducible from the analogy of our own earth remains unaffected. If Mars and Jupiter be at this moment inhabited by living creatures, it can only be because these orbs happen to be passing through the life-supporting period of their existence. We have shown that there is strong reason for believing this not to be the case; but if it is the case, this can only be regarded as a strange chance. For we have learned from the study of our earth that the life-supporting era of a planet is short compared with the duration of the planet's existence. It follows that any time selected at random in the history of a planet is far more likely to belong to one or other of the two lifeless eras, one preceding, the other following the life-supporting era, than to belong to this short era itself. And this present time *is* time selected at random with reference to any other orb in the universe than our own earth. We are so apt to measure all the operations of nature by our own conceptions of them, as well in space as in time, that as the solar system presents itself (even now) as the center of the universe, so this present time, the era of our own life, or of our nation's life, or of the life of man, or of the existence of organic beings on the earth, or (passing yet a grade higher) the era of our earth's existence as a planet, presents itself to us as the central era of *all* time. But what has been shown to be false with respect to space is equally false with respect to time. Men of old thought that the petty region in which they lived was the center of the universe. After this was shown to be false by Copernicus, Kepler, and Newton, men clung in turn to the conception that the solar system is central within the universe. The elder Herschel showed that this conception also is false. Even he, however, assigned to the sun a position whence the galaxy might be measured. But it begins to be recognized that this is not so. Nay, not only is the sun no suitable center whence to measure the stellar system, but the stellar system is for us immeasurable. The galaxy has no center and no limits; or rather we may say of it what Blaise Pascal said of the universe of space—its center is everywhere and its circumference nowhere. The whole progress of modern science tends to show that we must similarly extend our estimate of time. In former ages each generation was apt to regard its own era as critical in the earth's history; that is, according to their ideas, in the history of the universe itself. Gradually, men perceive that no generation of men, no nation, no group of nations, occupies a critical or central position in the history of even the human race upon earth, far less in the history of organic life. We may now pass a step higher, and, contemplating the infinity of time, admit that the whole duration of this earth's existence is but as a single pulsation in the mighty life of the universe. Nay, the duration of the solar system is scarcely more. Countless other such systems have passed through all their stages, and have died out, untold ages before the sun and his family began to be formed out of their mightly nebula; countless others will come into being after the life has departed from our system. Nor need we stop at solar systems, since within the infinite universe, without beginning and without end, not suns only, but systems of suns, galaxies of such systems, to higher and higher orders endlessly, have long since passed through all the stages of their existence as systems, or have all those stages yet to pass through. In the presence of time-intervals thus seen to be at once infinitely great and infinitely little—infinitely great compared with the duration of our earth, infinitely little by comparison with the eternities amid which they are lost—what reason can we have, when viewing any orb in space from our little earth, for saying *now* is the time when that orb is, like our earth, the abode of life? Why should life on that orb synchronize with life on the earth? Are not, on the contrary, the chances infinitely great against such a coincidence? If, as Helmholtz has well said, the duration of life on our earth is but the minutest "ripple in the infinite ocean of time," and the duration of life on any other planet of like minuteness, what reason can we have for supposing that those remote minute, and no way associated waves of life must needs be abreast of each other on the infinite ocean whose surface they scarcely ripple?

But let us consider the consequences to which we are thus led. Apart from theoretical considerations or observed facts, it is antecedently improbable that any planet selected at random, whether planet of our own system or planet attending on another sun than ours, is at this present time the abode of life. The degree of improbability corresponds to the proportion between the duration of life on a planet and the duration of the planet's independent existence. We may compare this proportion to that existing between the average lifetime of a man and the duration of the human race.

If one person were to select at random the period of a man's life, whether in historic, prehistoric, or future time, and another were to select an epoch equally at random, save only that it fell *somewhere* within the period of the duration of the human race, we know how exceedingly minute would be the probability that the epoch selected by the second person would fall within the period selected by the first. Correspondingly minute is the *a priori* probability that at this present epoch any planet selected at random is the abode of life. This is not a mere speculation, but an absolute certainty, if we admit as certain the fact, which few now question, that the period during which organic existence is possible on any planet is altogether minute compared with the duration of that planet's existence.

The same relation is probably true when we pass to higher systems. Regarding the suns we call "the stars" as members of a sidereal system of unknown extent (one of innumerable systems of the same order), the chance that any sun selected at random is, like our own sun at the present time, attended by a planetary system in one member of which at least life exists, is exceedingly small, if, as is probable, the life-supporting era of a solar system's existence is very short compared with the independent existence of the system. If the disproportion is of the same order as in the case of a single planet, the probability is of the same order of minuteness. In other words, if we select any star at random, it is as unlikely that the system attending on that sun is at present in the life-bearing stage as a system, as it is that any planet selected at random is at present in the life-bearing stage as a planet. This conclusion, indeed, may be regarded as scarcely less certain than the former, seeing that we as little doubt the relative vastness of the periods of our sun's existence before and after his existence as a supporter of life, as we doubt the relative vastness of the periods before and after the life-supporting era of any given planet. There is, however, one element of doubt in the case of the star. The very fact of the star's existence as a steady source of light and heat implies that the star is in a stage resembling that through which our own sun is now passing. It may be, for instance, that the prior stages of solar life are indicated by some degree of nebulosity, and the later stages by irregular variations or by such rapid dying out in brightness as has been observed in many stars. Yet a sun must be very nebulous indeed—that is, must be at a very early stage in its history—for astronomers to be able to detect its nebulosity; and, again, a sun must long have ceased to be a life-supporter before any signs of decadence measurable at our remote station, and with our insignificant available time-intervals for comparison, are manifested.

As to higher orders than systems of suns we cannot speculate, because we have no means of determining the nature of such orders. For instance, the arrangement and motions of the only system of suns we know of, the galaxy, are utterly unlike the arrangement and motions of the only system of planets we know of. Quite possibly systems of sun-systems are unlike either galaxies or solar systems in arrangement and motions. But if, by some wonderful extension of our perceptive powers, we could recognize the countless millions of systems of galaxies doubtless existing in infinite space, without, however, being able to ascertain whether the stage through which any one of those systems was passing corresponded to the stage through which our galaxy is at present passing, the probability of life existing anywhere within the limits of a galaxy so selected at random would be of the same order as the probability that life exists either in a planet taken at random or in a solar system taken at random. For though the number of the suns is enormously increased, and still more the number of subordinate orbs like planets (*in posse* or *in esse*), the magnitude of the time-intervals concerned is correspondingly increased. One chance out of a thousand is as good as a thousand chances out of a million, or as a million out of a thousand millions. Whether we turn our thoughts to planet, sun, or galaxy, the law of Nature (recognized as universal within the domain as yet examined), that the duration of life in the individual is indefinitely short compared with the duration of the type to which the individual belongs, assures us, or at leastrenders it highly probable, that in any member of any of these orders taken at random, *it is more probable that life is wanting than that life exists at this present time*. Nevertheless, it is at least as probable that *every member of every order—planet, sun, galaxy, and so onward to higher and higher orders endlessly—has been, is now, or will hereafter be, life-supporting "after its kind."*

In what degree life-supporting worlds, or suns, or systems are at this or any other epoch surpassed in number by those which as yet fulfill no such functions, or have long since ceased to fulfill them, it would only be possible to pronounce if we could determine the average degree in which the life-sustaining era of given orbs or systems is surpassed in length by the preceding and following stages. The life-sustaining orbs or systems may be surpassed many thousandfold or many millionfold in number by those as yet lifeless or long since dead, or the disproportion may be much less or much greater. As yet we only know that it must be very great indeed.

But at first sight the views here advanced may appear as repugnant to our ordinary ideas as Whewell's belief that perhaps our earth is the only inhabited orb in the universe. Millions of uninhabited worlds for each orb which sustains life! Surely that implies incredible waste! If not waste of matter, since according to the theory every orb sustains life in its turn, yet still a fearful waste of time. To this it may be replied, first, that we must take facts as we find them. And secondly, whether space or matter or time or energy appear to be wasted, we must consider that, after all, space and matter and time and energy are necessarily infinite, so that the portion utilized (according to our conceptions), being a finite portion of the infinite, is itself also infinite. Speaking, however, of the subject we are upon, if one only of each million of the orbs in the universe is inhabited, the number of inhabited orbs is nevertheless infinite. Moreover, it must be remembered that our knowledge is far too imperfect for us to be able to assert confidently that space, time, matter, and force, though not utilized according to our conceptions, are therefore necessarily wasted. To the ignorant savage, grain which is planted in a field instead of being used for food seems wasted, the wide field seems wasted, the the time wasted during which the grain is growing and ripening into harvest; but wiser men know that what looks like waste is in reality economy. In like manner the sun's rays poured on all sides into space so that his circling family receives but the 230 millionth portion, seem, to our imperfect conceptions, almost wholly wasted; but, if our knowledge were increased, we should perhaps form a far different opinion. So it may well be with the questions which perplex us when we contemplate the short duration of the life-sustaining condition of each world and sun and galaxy compared with the whole existence of these several orders. The arrangement which seems so wasteful of space and time and matter and force, may in reality involve the most perfect possible use and employment of every portion of space, every instant of time, every particle of matter, every form of force.—*Knowledge*.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING, MINING, ETC.—The Boston Sewage Works.—With full description of the system, a map showing general arrangement and discharge into the harbor, and two full pages of illustrations of tunnels, engines, etc. 8360
An Original Cantilever Bridge. 8362
Method of Working Low Beds of Auriferous Gravel.—With engraving. 8362
Hoisting from Great Depths.—Cost of pneumatic plant.—A new rope system. 8362

II. TECHNOLOGY.—Mechanical Aids to Decoration.—A machine for throwing pigment on paintings; tools for wood carving, etc. 8364
Automatic Postal Card and Envelope Distributor.—System by which postal cards can be automatically sold at street corners, etc.. 8366

III. ELECTRICITY, ETC.—Bimetallic Storage Batteries.—Batteries of Nobili, Schoenbein, Wheatstone, and others.—A new battery which prevents the production of free acid. 8367

IV. ART AND ARCHITECTURE.—Two Chimney Pieces in Wood.—With engraving. 8363
The Hummel Monument at Pressburg.—With engraving. 8363
An English Farm House.—With engraving. 8364
Earthenware as a Building Material. 8364
Masonry and Brickwork in Fires. 8364
House at St. George's Hills, Weybridge.—With engraving. 8365
Builders' Quantities.—Builders' estimates and surveyors' bills of quantity.—Agreements between architects and builders. 8365

V. ASTRONOMY, ETC.—Prof. Palmieri's Udometer and Anemometrograph.—The udometer in connection with a rain collector.—Anemometer, velocity receiver, and receiver for direction of wind. 8366
Costiesco's Field Quadrant.—With engraving. 8367
Life in Other Worlds.—By R. A. PROCTOR.—Time a necessary element in natural development.—Highly developed life in Jupiter, but not on Mars.—Are the "stars" life-supporting? 8374

VI. ARCHÆOLOGY.—Stone Piles in Washington Territory.—Their origin.—A letter. 8363

VII. BOTANY, ETC.—The Essential Chemical Elements of Plants.—Abstract of a paper read by THOS. JAMIESON before the British Association. 8371
Bulbus Calanthes.—With description and engraving. 8373

VIII. PATHOLOGY, PHYSIOLOGY, HYGIENE.—Outwitting our Health Officers. 8365
On the Micro-Organisms of Potable Waters; their Life in Carbonic Waters.—A valuable paper by Dr. T. LEONE. 8371

IX. MISCELLANEOUS.—Education in the United States.—Abstract of a circular by Dr. PHILBRICK. 8365
Education of the American Citizen.—A lecture by Dr. R. H. THURSTON, Director of Sibley College, Cornell University. 8368
The Parisian Somersault Turners.—A mechanical toy. 8370

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 41 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

Munn & Co., 361 Broadway, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.